

World Technology Evaluation Center



WTEC

WTEC Panel Report on

Submersibles and Marine Technologies In Russia's Far East and Siberia

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August 1996

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WTEC PANEL ON SUBMERSIBLES AND MARINE TECHNOLOGIES IN RUSSIA'S FAR EAST AND SIBERIA

Sponsored by the National Science Foundation and the Office of Naval Research of the United States Government

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INTERNATIONAL TECHNOLOGY RESEARCH INSTITUTE WTEC PROGRAM

The World Technology Evaluation Center (WTEC) at Loyola College (previously known as the Japanese Technology Evaluation Center, JTEC) provides assessments of foreign research and development in selected technologies under a cooperative agreement with the National Science Foundation (NSF). Loyola's International Technology Research Institute (ITRI), R.D. Shelton Director, is the umbrella organization for WTEC. Paul Herer, Senior Advisor for Planning and Technology Evaluation at NSF's Engineering Directorate, is NSF Program Director for WTEC. Other U.S. government agencies that provide support for the program include the National Aeronautics and Space Administration, the Department of Energy, the Department of Commerce, and the Department of Defense.

WTEC's mission is to inform U.S. policy makers, strategic planners, and managers of the state of selected technologies in foreign countries in comparison to the United States. WTEC assessments cover basic research, advanced development, applications, and commercialization. Small panels of about six technical experts conduct WTEC assessments. Panelists are leading authorities in their field, technically active, and knowledgeable about U.S. and foreign research programs. As part of the assessment process, panels visit and carry out extensive discussions with foreign scientists and engineers in universities and in industry and government labs.

The ITRI staff at Loyola College helps select topics, recruits expert panelists, arranges study visits to foreign laboratories, organizes workshop presentations, and finally, edits and disseminates the final reports.

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WTEC Panel on

**SUBMERSIBLES AND MARINE TECHNOLOGIES
IN RUSSIA'S FAR EAST AND SIBERIA**

FINAL REPORT

August 1996

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ABSTRACT

This report is a review of research submersible vehicles and other marine technologies in Siberia and the Russian Far East. It complements a 1994 WTEC report covering submersible technologies in Ukraine and European Russia. The panel found that two institutions in Vladivostok have extensive developments and experience in operating remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs). In particular, two prototype AUVs developed by the Institute for Marine Technology Problems (IMTP) are rated at 6000 meters operating depth, one of which has logged 160 working dive missions greater than 4000 meters. The WTEC panelists concluded that IMTP had more AUV operating experience than all U.S. programs combined. The panel also visited several centers of excellence in the Novosibirsk area, including the Institute of Thermodynamics and Applied Mechanics, which is world-class facility for research on aerodynamics, including eight wind tunnels achieving air speeds up to Mach 25. Other institutes the panel visited are doing research in computer software development, marine biology and bioorganic chemistry, physics, and energy research. The panel sensed a new commitment to openness about R&D work being done in the institutes it visited, and found that several institutes already have developed extensive international relationships. However, the panel also perceived that many of these institutes are in a state of crisis, with declining government funding and mixed results in efforts to spin off profit-making enterprises. Some research institutes have expired and more will cease to exist because of the lack of basic funding by the government

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FOREWORD

The National Science Foundation (NSF) has been involved in funding technology assessments comparing the United States and foreign countries since 1983. A sizable proportion of this activity has been in the Japanese Technology Evaluation Center (JTEC) and World Technology Evaluation Center (WTEC) programs. NSF has supported more than thirty JTEC and WTEC studies over a wide range of technical topics.

As U.S. technological leadership is challenged in areas of previous dominance such as aeronautics, space, and nuclear power, many governmental and private organizations seek to set policies that will help maintain U.S. strengths. To do this effectively requires an understanding of the relative position of the United States and its competitors. The purpose of the JTEC/WTEC program is to assess research and development efforts in other countries in specific areas of technology, to compare these efforts and their results to U.S. research in the same areas, and to identify opportunities for international collaboration in precompetitive research.

Many U.S. organizations support substantial data gathering and analysis efforts directed at nations such as Japan. But often the results of these studies are not widely available. At the same time, government and privately sponsored studies that are in the public domain tend to be "input" studies; that is, they provide enumeration of inputs to the research and development process, such as monetary expenditures, personnel data, and facilities, but do not provide an assessment of the quality or quantity of the outputs obtained.

Studies of the outputs of the research and development process are more difficult to perform because they require a subjective analysis performed by individuals who are experts in the relevant technical fields. The NSF staff includes professionals with expertise in a wide range of disciplines. These individuals provide the technical expertise needed to assemble panels of experts who can perform competent, unbiased, technical reviews of research and development activities.

Specific technologies, such as telecommunications, biotechnology, microelectromechanical systems, and advanced materials, are selected for study by government agencies that have an interest in obtaining the results of an assessment and are able to contribute to its funding. A typical assessment is sponsored by two to four agencies. In the first few years of the program, most of the studies focused on Japan, reflecting concern over Japan's growing economic prowess. Studies were largely defined by a few federal mission agencies that contributed most of the funding, such as the Department of Commerce, the Department of Defense, and the Department of Energy.

The early JTEC methodology involved assembling a team of U.S. experts (usually six people from universities, industry, and government), reviewing the extant literature, and writing a final report. Within a few years, the program began to evolve. First we added site visits. Panels traveled to Japan for a week and visited twenty to thirty industrial and research sites. Then, as interest in Japan increased, a larger number of agencies became involved as cosponsors of studies. Over the ten-year history of the program, fifteen separate branches in six agencies of the federal government (including NSF) have supported JTEC and WTEC studies.

Beginning in 1990, we began to broaden the geographic focus of the studies. As interest in the European Community (now the European Union) grew, we added Europe as an area of study. With the breakup of the former Soviet Union, we began organizing visits to previously restricted research sites opening up there. These most recent WTEC studies have focused on identifying opportunities for cooperation with researchers and institutes in Russia, the Ukraine, and Belarus, rather than on assessing them from a competitive viewpoint.

In the past several years, we also have begun to substantially expand our efforts to disseminate information. Attendance at JTEC/WTEC workshops (in which panels present preliminary findings) has increased, especially industry participation. Representatives of U.S. industry now routinely number 50% or more of the total attendance, with a broad cross section of government and academic representatives making up the remainder. JTEC and WTEC studies have also started to generate increased interest beyond the science and technology community, with more workshop participation by policymakers and better exposure in the general press (e.g., *Wall Street Journal*, *New York Times*). Publications by JTEC and WTEC panel members based on our studies have increased, as have the number of presentations by panelists at professional society meetings.

The JTEC/WTEC program will continue to evolve in response to changing conditions in the years to come. NSF recently has authorized new JTEC/WTEC initiatives aimed at the following objectives:

- Disseminating the results of JTEC/WTEC studies via the Internet. Twelve of the most recent JTEC/WTEC final reports are now available on the World Wide Web (<http://itri.loyola.edu>) or via anonymous FTP ([ftp.wtec.loyola.edu/pub/](ftp:wtec.loyola.edu/pub/)). Viewgraphs from several recent workshops are also on the Web server.
- Expanding opportunities for the larger science and technology community to help define and organize studies.
- Increasing industry sponsorship of JTEC and WTEC studies.

The latter two objectives are now being served under the recently inaugurated Community-Initiated State-of-the-Art Reviews (CISAR) initiative. As of this writing, JTEC/WTEC has formed partnerships with university-industry teams, with partial funding from industry, to carry out three CISAR studies. These cover the Korean semiconductor industry, electronics final assembly technologies in Pacific Rim countries, and civil infrastructures in Pacific Rim countries respectively. Several other topics are under consideration. Further information on the CISAR initiative is available on the JTEC/WTEC WWW server (<http://itri.loyola.edu/cisar.htm>) or by contacting the JTEC/WTEC office.

In the end, all government-funded programs must answer the question, *How has the program benefited the nation?* A few of the benefits of the JTEC/WTEC program follow:

- JTEC studies have contributed significantly to U.S. benchmarking of the growing prowess of Japan's technological enterprise. Some have estimated that JTEC has been responsible for over half the major Japanese technology benchmarking studies conducted in the United States in the past decade. JTEC reports have also been widely cited in various competitiveness studies.
- These studies have provided important input to policymakers in federal mission agencies. JTEC and WTEC panel chairs have given special briefings to senior officials of the Department of Energy, to the National Aeronautics and Space Administration (NASA) Administrator, and even to the President's Science Advisor.
- Studies have been of keen interest to U.S. industry, providing managers with a sense of the competitive environment internationally. Members of the recently completed study on satellite communications have been involved in preliminary discussions concerning the establishment of two separate industry/university consortia aimed at correcting the technological imbalances identified by the panel in its report.
- Information from JTEC and WTEC studies also has been valuable to both U.S. and foreign researchers, suggesting a potential for new research topics and approaches, as well as opportunities for international cooperation. One JTEC panelist was recently told by his Japanese hosts that, as a result of his observations and suggestions, they have recently made significant new advances in their research.
- Not the least important is the educational benefit of the studies. Since 1983 over 200 scientists and engineers from all walks of life have participated as panelists in the studies. As a result of their experiences, many have changed their viewpoints on the significance and originality of foreign research. Some have also developed lasting relationships and ongoing exchanges of information with their foreign hosts as a result of their participation in these studies.

As we seek to refine the JTEC/WTEC program in the coming years, improving the methodology and enhancing the impact, program organizers and participants will continue to operate from the same basic premise that has been behind the program from its inception: the United States can benefit from a better understanding of cutting-edge

research that is being conducted outside its borders. Improved awareness of international developments can significantly enhance the scope and effectiveness of international collaboration and thus benefit all of the United States' international partners in collaborative research and development efforts.

Paul J. Herer
National Science Foundation
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EXECUTIVE SUMMARY

The World Technology Evaluation Center (WTEC) was commissioned by the Office of Naval Research (ONR) and the National Science Foundation (NSF) to assess the technology level of submersible vehicles and other marine technologies in Siberia and the Russian Far East.

This study would complement the *WTEC Panel Report on Research Submersibles and Undersea Technologies* (June 1994), which had been funded by the Defense Advance Research Projects Agency (DARPA) and NSF but which was limited in geographic scope to European Russia and Western Europe.

A panel of eight experts was organized by WTEC for the new study. To maintain continuity, five of the individuals from the first study in 1993 were included in this group of experts. This new WTEC panel visited 18 sites, including universities, government research institutes, an industrial site, and a marine biology laboratory ship. During the period from October 23 through November 1, 1995, the WTEC team spent approximately one week each in Vladivostok, Russian Far East, and in Akademgorodok at Novosibirsk, Siberia. As well as gathering information, the team made many contacts with officials and researchers in the Russian scientific community and introduced the Navy's Scientific Opportunities Program for possible support of scientific projects in Russia.

The following are highlights of the WTEC panel's observations:

GENERAL

In comparison to the WTEC team's observations of 1993, the impact of the shift in national priorities and the economic turbulence of Russia since 1990 was more evident. The funding level from government sources for institutes and university research has dropped precipitously. The Russian Academy of Sciences (RAS) budget in 1994 (in undeinflated rubles) was only 21% of the 1990 budget in rubles. The best laboratories are managing to continue operations through budding entrepreneurship and adapting to market forces. Many are doing commercial research and development for both Russian and foreign companies as well as producing unique instrumentation and special laboratory equipment for sale abroad. Some research institutes have expired and more will cease to exist because of the lack of basic funding by the government. In some cases, there may be no alternative to government funding because the research cannot be applied. In other cases, high taxes imposed by various government levels in Russia might offset low labor costs to the extent that the enterprises may not be competitive in the world marketplace. In still other cases, lack of access to markets or the limited vision of institute management may be partially responsible for the demise of an institute.

Although most scientific personnel might prefer to stay with their institutes, a number are leaving because of very low salaries, failure to receive pay for prolonged periods of time, or the attraction of improved compensation in the emerging private sector. In Vladivostok, for example, computer technicians and some other technical personnel have left research institutes to work in private business. Fewer young people are entering science because opportunities that are business connected offer more potential. The banking industry was cited as responsible for the dearth of computer science personnel available at one institute which the WTEC team visited. On the other hand, fewer technicians and young scientists are leaving their profession in the Novosibirsk area because of a fair amount of scientific activity, reasonable operating levels of the institutes, and finally the isolated location with little prospect of finding housing in another city.

UNMANNED SUBMERSIBLES

Although the 1993-1994 study of European Russia and Ukraine had concluded that there was only limited interest in Russia for unmanned research submersibles, two institutions in Vladivostok proved to have extensive developments in remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs). While exhibiting three different ROVs, Far Eastern State Technical University reported that their researchers and design group had developed 39 ROVs since 1970. During this same period, the Institute for Marine Technology Problems (IMTP) built and operated several prototype and operational AUVs.

The AUV program at the Institute of Marine Technology Problems was surprisingly more extensive than was anticipated by the WTEC team — in design capability, vision for future designs, and operational experience. One prototype, designated AUV L-2, rated at 6000 meters operating depth, has logged 160 working dive missions greater than 4000 meters. The current model MT-88 is also rated at 6000 meters operating depth. The WTEC panelists concluded that IMTP had more AUV operating experience than all U.S. programs combined.

COMPUTER SOFTWARE DEVELOPMENT

Although most institutes in the Russian Far East have not had access to the most powerful computers, due to Western export restrictions, excellent efficiency has been obtained from Intel 486-based hardware through the crafting of superior computer codes and algorithms. Among the 10 research institutes that were visited, 37 different computer software-related projects were discussed or demonstrated. Many projects were in tomography, in various methods of physical modeling, and in signal or visual target detection in high noise. See Appendix C for a summary of computer-related projects.

Except for Novosibirsk, many computer scientists are leaving the research community for commercial systems work, especially for the new banking industry.

APPLIED AERODYNAMICS, HYDRODYNAMICS, AND MECHANICS

The Institute of Thermodynamics and Applied Mechanics, Novosibirsk, is world-class in research on aerodynamics, with eight wind tunnels achieving air speeds up to Mach 25.

Significant work was shown in the modeling of explosive effects such as the focusing of shock waves, numerical description of "bubbly detonation," and self-forging projectiles. In addition, the Lavrentyev Institute of Hydrodynamics demonstrated explosive methods for welding normally incompatible metals and for explosively coating metals with ceramics and other materials.

MARINE BIOLOGY AND BIOORGANIC CHEMISTRY RESEARCH

The Pacific Institute for Bioorganic Chemistry (PIBC), Vladivostok, conducts important research concerning a number of bioactive substances from marine and terrestrial flora and fauna that are accessible (and some unique) to the Russian Far East. In contrast to Western institutes, which seldom develop, manufacture, and sell commercial products, PIBC produced several products commercially. The results of the institute's research, which identifies and synthesizes biosubstances, have produced medicines, food supplements and additives; improved agriculture; and developed biotechnology for commercial uses. The institute has an exceptionally large reference collection of bioactive substances — about 8000 strains.

The research vessel *Akademik Oparin*, operated by PIBC out of Vladivostok, is an important resource that is now available for cooperative biomedical marine research. The ship, which is equipped to support 30 scientists in the field for extended periods, can be chartered from PIBC at very reasonable costs in comparison to any other type of research vessel.

The Russian Academy of Sciences, Far Eastern Branch, has 15 research vessels, ranging up to 6280 tons displacement, which may be the largest research fleet anywhere in the world that is under the management of a single organization. Unfortunately this impressive block of research assets is essentially inactive for lack of funding for seagoing research projects. As with the *Akademik Oparin*, the other research vessels are available for charter and joint research projects. Meanwhile, in order to maintain a minimum level of operational capability, some of the research vessels are now carrying passengers, consumer goods, and automobiles from ports on the Pacific Rim. This is both a sign of a desperate situation and of the Russian ability to persevere during adversity.

The Institute for Marine Biology studies the biology and ecosystems of coastal waters in the Russian Far East, including concern for a major port development by China and North Korea at their border with Russia.

PHYSICS AND ENERGY RESEARCH

Excellent work in improved design of battery materials was reported. The Institute of Chemistry, Vladivostok, has developed new cathodic materials for lithium chemical current sources with power-consumption in the range 3.5 to 4.8 kW hr/kg.

Significant emphasis on laser development was seen at the Institute of Automation and Electrometry, Novosibirsk. Research emphasized methods for producing stable solid state lasing, separation techniques using "light-induced drift" and commercial production of a precision laser table and laser manufacturing of precision optical filters and diffraction gratings.

OVERALL STRENGTHS OF RUSSIAN SCIENCE

- New commitment to openness about R&D work being done in the institutes
- Desire to maintain national scientific capabilities
- Scientists' strong theoretical and fundamental background in science
- Ability to "make do"
- Willingness to cooperate outside Russia
- Well educated and experienced research personnel
- Excellence in mathematical modeling
- Lower cost of labor at all levels

LIMITATIONS OF RUSSIAN SCIENCE

- Uncertainties and inconsistencies of Russian government policies
- Few alternative sources of funding other than the government
- Physical plant becoming obsolete
- Experienced personnel leaving science
- Lack of some modern equipment, especially computers
- Entrepreneurial spirit not yet well developed
- Tax structure that reduces competitiveness and discourages some cooperative ventures
- Major cutbacks in funding from traditional customers (i.e., defense and space programs)

OPPORTUNITIES FOR COOPERATION

- Joint ventures to upgrade equipment
- Joint ventures using Russian resources
- Joint ventures using Russian science and technology with Western engineering and marketing
- Exchange of scientists and students

PROPOSALS TO SCIENTIFIC OPPORTUNITIES PROGRAM

Subsequent to the visit of the WTEC panel, as of April 30, 1996, a total of 29 proposals for research support in Siberia and the Russian Far East had been received by the Scientific Opportunities Program at ONR. The proposals represent the strengths in the marine-related science and technologies of the nine institutes which submitted them. See Appendix B for a complete listing.

CHAPTER 1

OVERVIEW

Brad Mooney

BACKGROUND AND INTRODUCTION

The World Technology Evaluation Center (WTEC) is administered by Loyola College, Baltimore, Maryland. In May 1993 and November 1995, WTEC organized and sent two small groups of experts to the former Soviet Union and to Western Europe to review and assess the state of submersibles and undersea technologies in these areas. Funding for the two projects was provided by the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense, the Office of Naval Research (ONR, U.S. Navy) and the U.S. National Science Foundation (NSF).

The first expert team consisted of 10 persons; the second, eight, representing the key technical areas of undersea engineering. Government personnel representing appropriate agencies and the project sponsors constituted roughly one third of each team. The rest were from industry, academe, and the private sector. Duration of each of the trips was approximately two weeks.

While the intended focus of these visits was the state of deep submergence technologies in the former USSR, more than half the sites the teams visited were organizations that build marine equipment or are engaged in various other types of marine research. Therefore, the reader will note that several marine-related areas — other than undersea vehicles — are discussed in this report. This was also true of the first study trip, the results of which were published by WTEC in 1994 as *WTEC Panel Report on Research Submersibles and Undersea Technologies*.¹

¹ This and other WTEC reports are now available on the World Wide Web (<http://itri.loyola.edu>) or via anonymous FTP ([ftp.wtec.loyola.edu/pub/](ftp:wtec.loyola.edu/pub/)).

The primary sites for the May 1993 study trip were to be in European Russia and the Ukraine. However, since team members would be passing through Western Europe, it was decided to visit selected organizations there as well. About a week was spent by some of the panel members visiting various facilities in the United Kingdom, France, and Finland. The European facility visits provided a useful background on undersea technologies prior to entering the former Soviet Union.

The actual time spent in Russia and in the Ukraine was only six days. Therefore, the expert panel was divided into teams of two or three people to make the actual site visits. In this way, 23 sites could be visited in Russia and 5 in the Ukraine. Complete details of this trip were reported at a workshop held in Washington, DC, in July 1993 and published in WTEC's 1994 report (cited above).

Clearly, this brief in-country period made it impossible to visit important facilities in Siberia and in the Russian Far East, even though the group was urged to do so. Understanding that additional site visits should be made in these areas to have a complete assessment, WTEC organized the second study trip for October 1995.

The expert panel for the second trip consisted of:

- RAdm. J. Bradford Mooney*, USN (Ret), Panel Chair; President, J. B. Mooney & Associates, consultant
- Dr. Michael J. DeHaemer*, Director, WTEC (now at ASM International)
- Mr. Hassan B. Ali, Research Physicist, Naval Research Laboratory — Stennis Space Center (now at ONR Tokyo)
- Mr. D. Richard Blidberg*, Director, Autonomous Undersea Systems Institute
- Mr. Sergei Chechin, consultant to WTEC
- Mr. John C. Moniz, Science Opportunities Program, Office of Naval Research
- Mr. Larry L. Gentry*, Program Manager, Lockheed Missiles & Space Company
- Dr. Don Walsh*, President, International Maritime Inc., consultant

*These members also were on the first study trip.

The 1995 WTEC panel intended to survey the Russian Far East for marine-relevant technologies, to establish contacts with the Far East and the Siberian branches of the Russian Academy of Sciences, and to cultivate continuing relationships with the various institutes and organizations visited. They visited 12 institutes and 6 other sites in Vladivostok and at Akademgorodok, the "Academic City" near Novosibirsk in Siberia.

The Vladivostok sites were, for the most part, involved in undersea vehicles and ocean sciences. At Akademgorodok much less emphasis was placed on ocean problems, and the institutes visited represented a wider array of research efforts.

In December 1995 an open workshop was held at NSF in Washington, D.C., where panel members reported their findings from the second study trip. Also, specially invited representatives from some of the Russian sites visited were present to assist in answering questions asked by the attendees.

This report completes WTEC's publication of results from the second study trip and marks the completion of this two-part survey project. In summary, the two panels of experts have presented an assessment of important marine-related work in the former Soviet Union from the Black Sea to the shores of the Baltic and to the Pacific Ocean.

This publication, together with WTEC's 1994 report, offer a useful overview of the state of undersea technologies and ocean sciences in a part of the world now undergoing tremendous change. For some, this change means both risk and favorable future opportunity. Therefore, it is hoped that those interested in developing joint efforts in Russia and the Ukraine will find this WTEC work useful in helping to avoid uncertainty while locating promising opportunities for future cooperation and development.

REVIEW OF SITES VISITED

Vladivostok

Presidium of the Far Eastern Branch of the Russian Academy of Sciences (FEB RAS)

The study team was hosted by Academician George B. Elyakov, Vice President of the Russian Academy of Sciences (RAS), and Chairman of the Far Eastern Branch (FEB). The FEB RAS, founded a quarter century ago, is headquartered in Vladivostok. The branch has six regional centers and is composed of 35 institutes, two native preserves, and one special marine preserve. The three preserves are used for science and environmental protection studies. The Magadan Territorial Center for Arctic studies has a cooperative program with the University of Alaska, Fairbanks. A major goal of the branch's efforts is the study of the use of resources, both on land and at sea, of the Russian Far East. The total staff of the FEB is a little over 8,000. There are 10 academicians in the FEB.

The branch has the largest research fleet of the RAS. There are 15 ships ranging in size from a few hundred tons to over 6200 tons. Most of this fleet is homeported in Vladivostok. The majority of these vessels are currently inactive due to lack of funding.

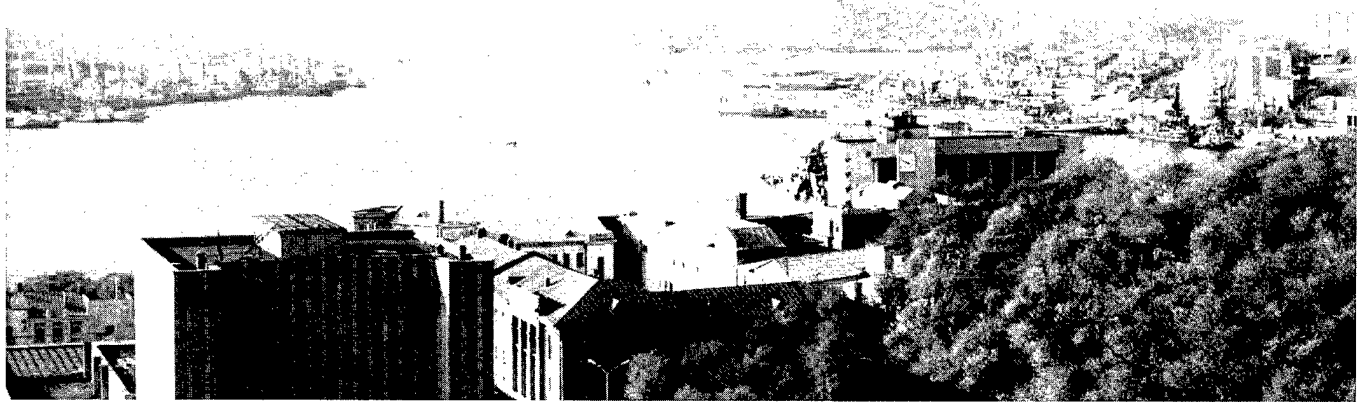


Fig. 1.1. Vladivostok harbor, October 1995

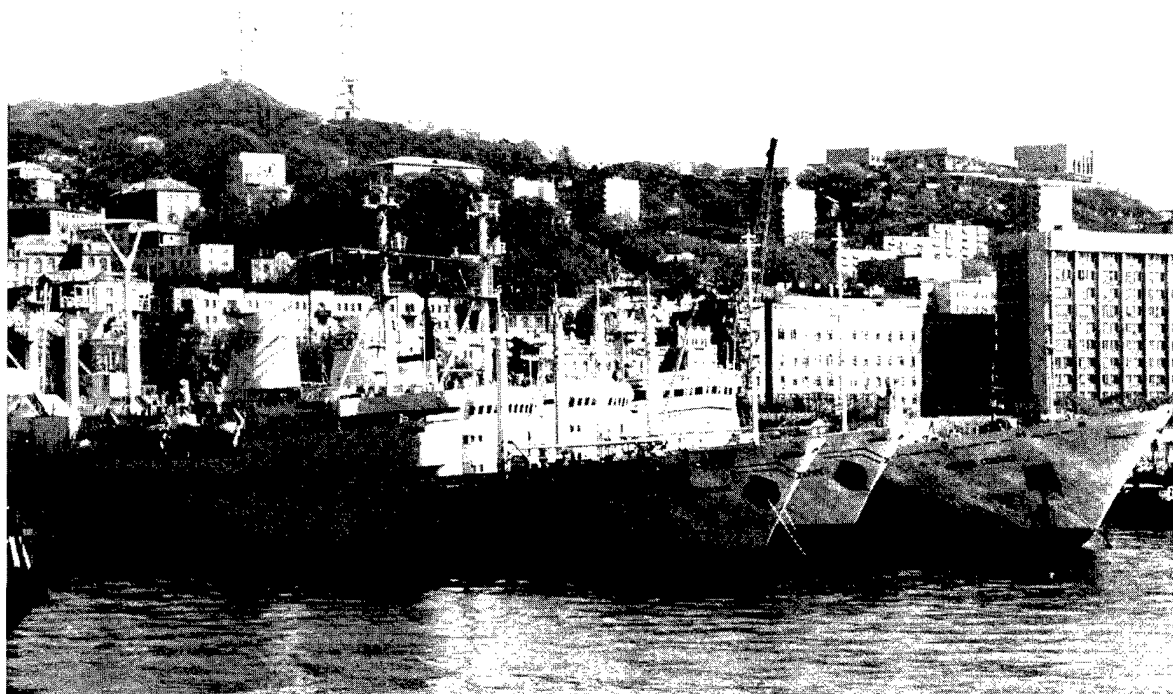


Fig. 1.2. Inactive oceanographic research vessels in Vladivostok harbor.

The major research directions of FEB institutes are earth sciences, biology, biotechnology, physics and technical sciences, chemistry, and the social sciences. Academician Elyakov said that funding in the branch is now half what it was before Perestroika. He encourages and supports joint projects with other countries that will use his people and facilities.

The Far Eastern State Technical University (FESTU)

Founded in 1899 as the "Oriental Institute," since 1923 the "Far Eastern Polytechnical Institute," it was renamed by decree of the Russian Federation government in December 1992. Overall, FESTU is reported to rank in the top 100 Russian universities. The university has approximately 10,000 students and four branch campuses. A faculty of 700 includes three academicians, 100 doctors of science, and 400 candidates for doctors of science ("candidate" is roughly equivalent to Ph.D.).

Among the disciplinary areas covered by the university's 18 major departments are electrical engineering, radio and instrumentation, natural sciences, architecture, naval engineering, economics and management, mechanical engineering, heat and power engineering, and the humanities. A six-year program is offered for a bachelor's diploma degree in naval engineering. Ph.D. programs are offered in ocean science, ship construction, and other fields in technology, economics, math, and philosophy. The humanities program emphasizes technical language understanding in English, Chinese, Japanese, and Korean. Approximately 36 students from different countries are enrolled in FESTU.

Academician Gennady Turmov, president of FESTU, showed the WTEC team four ocean engineering projects. The first two were remotely operated vehicles (ROVs), the third used optical fibers as sensors for ocean tomography, and the fourth was an artificial neural network to interpret sensor data. The team was told that 39 ROVs have been designed by FESTU. Most of them were designed for hydroacoustical, magnetic, and photographic work. The team saw three of these ROVs. FESTU's two 6,000 meter *Roby* submersibles (Fig. 1.3) were used to recover the flight recorder from Korean Airlines' Flight 007 in the Sea of Japan. These vehicles were designed for rescue operations, taking photo surveys, and coring. They are also equipped with manipulators for work tasks.

The Pacific Oceanological Institute (POI)

Founded in 1973, the Pacific Oceanological Institute in Vladivostok is the major institute of the FEB RAS. It has a staff of over 600, including approximately 270 scientists. Researchers at the institute conduct experiments along the Pacific Rim from the Bering Sea to the South China Sea. In addition, POI actively participates in international projects such as the World Ocean Circulation Experiment (WOCE).

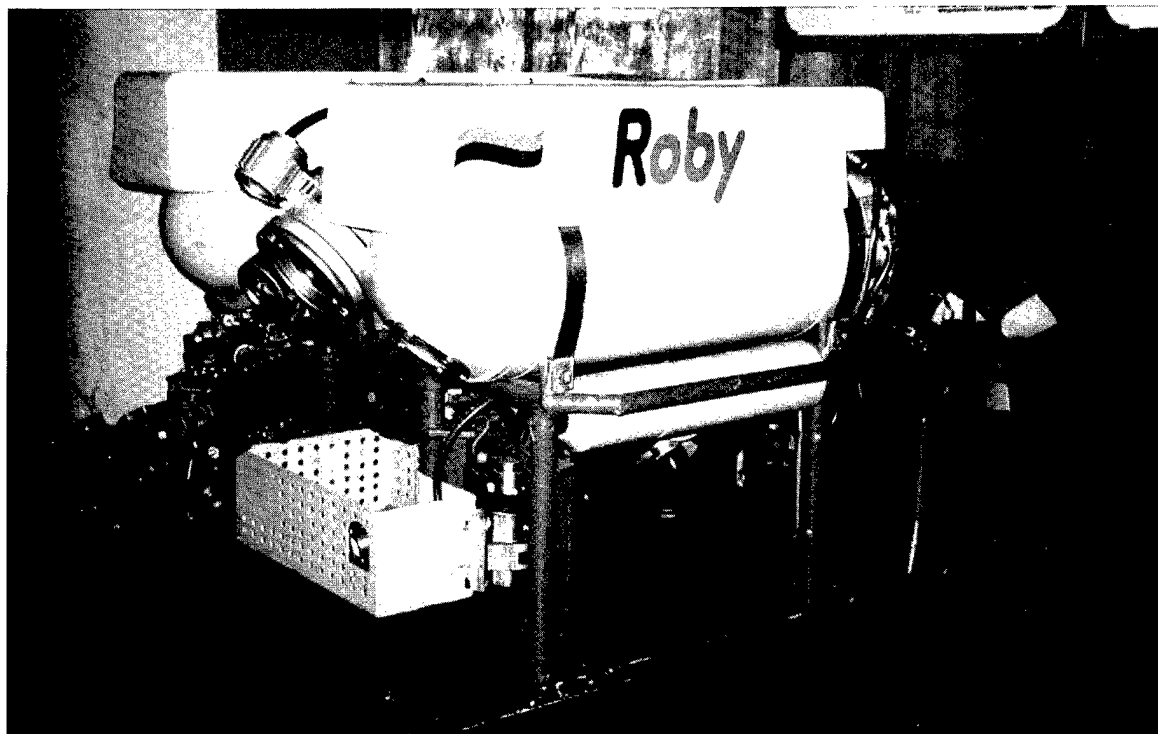


Fig. 1.3. ROV *Roby* (Far Eastern State Technical University, Vladivostok).

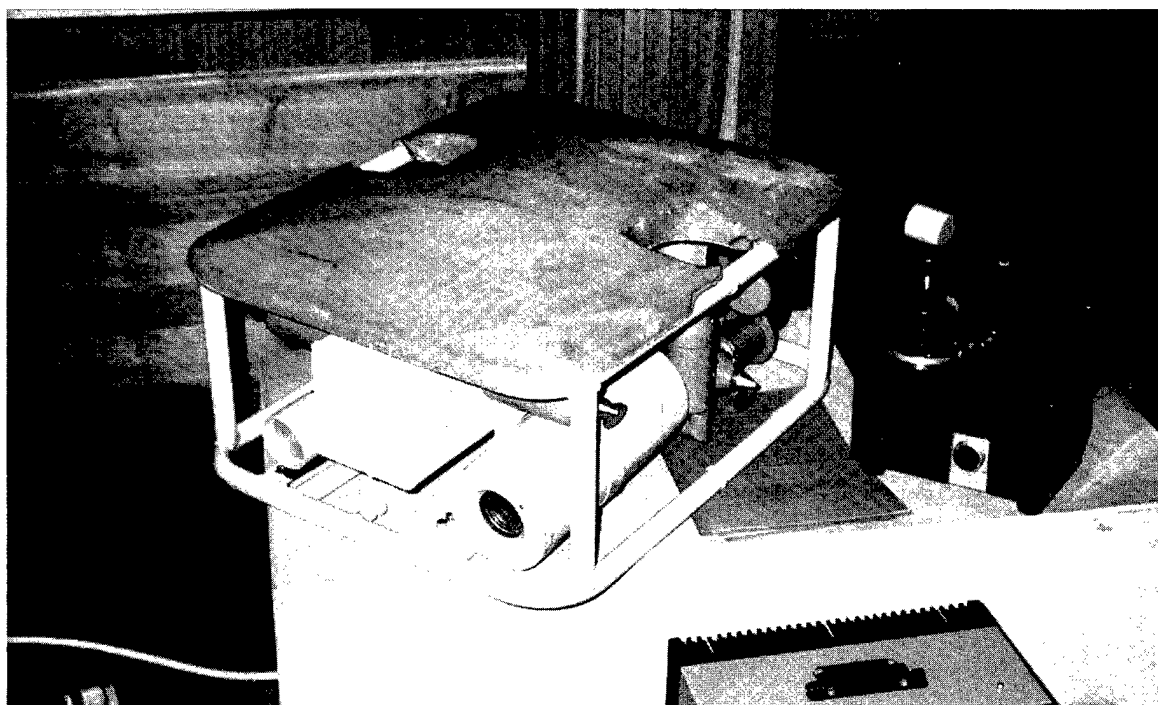


Fig. 1.4. *Anties* ROV packaged system (Far Eastern State Technical University, Vladivostok).

The POI laboratories and departments focus on the following research areas:

- Experimental and theoretical oceanology investigations of ocean processes and dynamics
- Underwater acoustics
- Ocean-atmosphere interaction
- Assessment of the status of water ecosystems
- Geological/geophysical investigations of the sea bottom

The Institute of Marine Technology Problems (IMTP)

The IMTP was founded in 1988 by Academician Mikhail D. Ageev, who is also a fellow of the U.S. Marine Technology Society. The scientific staff of the institute consists of 90 people. One is an academician of the RAS, one a corresponding member of the RAS, three are academicians of the Academy of Engineering Sciences, and 19 are professors and doctors of science.

Facilities include about 2,000 square meters of laboratory space, computer-aided design (CAD) engineering capabilities, experimental production workshops, a high pressure (21,900 psi or 49,200 ft.) test chamber, and a small research vessel. The high pressure facility is located at a separate site from the main institute, while the research vessel is in Vladivostok's inner harbor.

Scientific investigations and technical developments are carried out in underwater robotics, hydrophysics, renewable energy sources, and marine ecological systems monitoring. The work in underwater robotics actually began in the early 1970s when this technical staff was part of another institute. Some of their AUVs were built during this time.

The primary programs of the IMTP are as follows:

- Development of new methods and principles to utilize AUVs for research and for exploring the ocean. Several AUVs have been built since the 1970s (Figs 1.5-1.7); most have operating depth capabilities down to 6000 m.
- Hydrophysics, investigating large scale inhomogeneities of the water medium.
- Renewable energy resources and nontraditional energetics. This laboratory group conducts resource evaluations of renewable power sources as well as investigations into new alternative energy technologies.
- Development of automated systems for ecological research and monitoring the water medium and aquaculture using AUVs designed and built at the institute.

The institute has maintained close scientific and technical contacts with universities, institutes, and companies in China, France, South Korea, and the United States. It has built specialized AUVs for customers in the People's Republic of China, in South Korea, and in the United States.

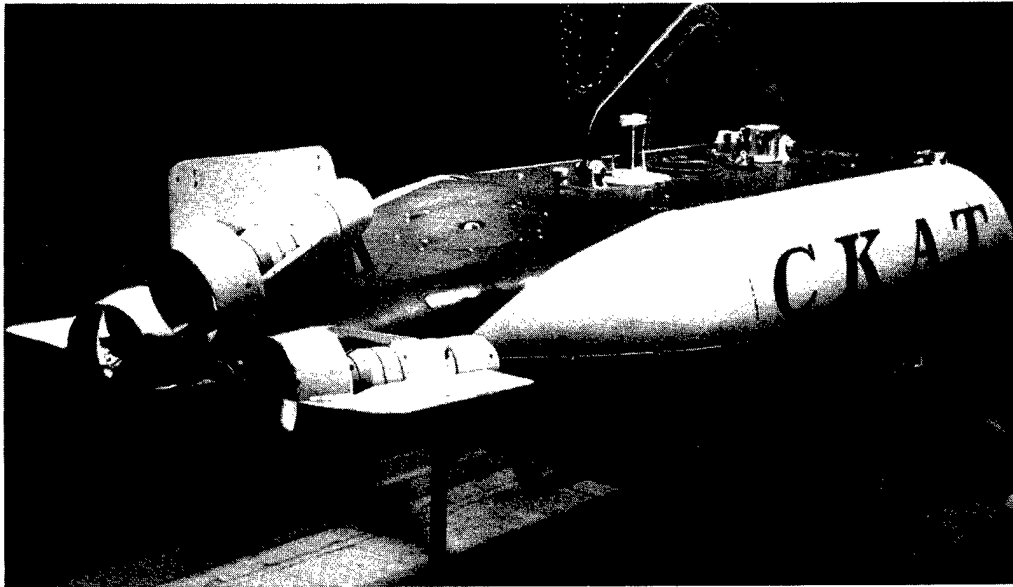


Fig. 1.5. 1970s era ROV *SKAT* (Institute for Marine Technology Problems, Vladivostok).

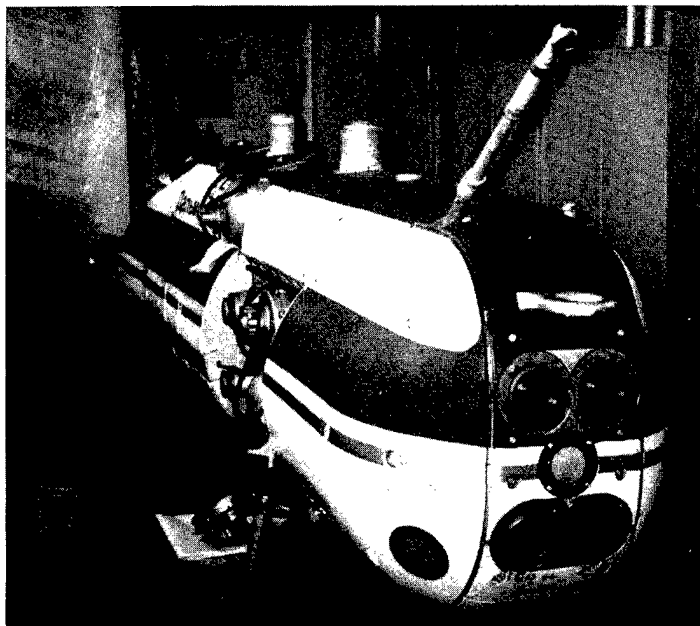


Fig. 1.6. *MT-88* autonomous underwater vehicle. Bow of view shows four electromagnets for detachable iron ballast plates (Institute for Marine Technology Problems, Vladivostok).

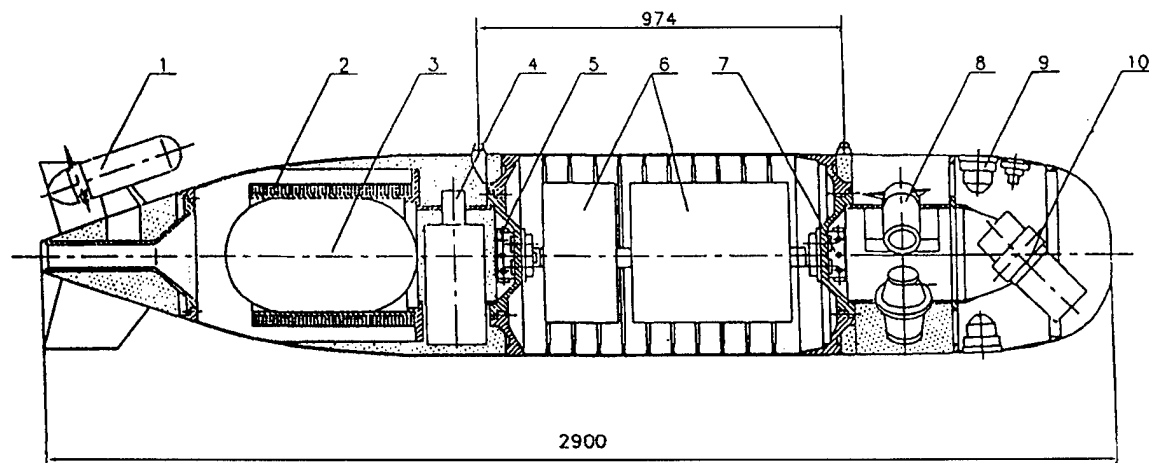


Fig. 1.7. The constructive base of the *Tunnel Sea Lion*. 1—Main Thrusters (3); 2—Fiberoptic Cable Spool; 3—Ballasting Vessel; 4—Transceiver; 5—Connection Box; 6—Main Battery and Electronics; 7—Connection Box; 8—Lateral Thrusters (2); 9—Sonar Transducers (5); 10—TV Camera Housing (Institute for Marine Technology Problems, Vladivostok).

The Pacific Institute of Bioorganic Chemistry (PIBC)

The PIBC was founded in 1964. Academician Elyakov has been its director for 30 years. The primary research focus is on the study of marine organisms at the molecular level. This direction offers the greatest potential for discovery of bioactive substances that can be used for the benefit of man.

The work of the PIBC has attracted foreign interest from organizations such as the National Institutes of Health, major drug companies, and the Harbor Branch Oceanographic Institution (U.S.). Foreign organizations are very interested in the 8,000 strain reference collection developed by PIBC. The Institute has a staff of 350, which includes 70 Ph.D.s and 25 doctors of science. Many of the support staff are involved with the operation and maintenance of the research vessel *Akademik Oparin*.

The institute now produces some commercial products which are sold on the market, but since it is part of the government (as part of the FEB RAS), institute researchers do not enjoy much freedom of action. Director Elyakov said that the institute's dream is to set up a company, independent of the government, to develop and market a variety of commercial products based on their biotechnology discoveries.

The Research Vessel Akademik Oparin

The WTEC team visited and inspected the *Akademik Oparin* in port in Vladivostok's inner harbor (Fig. 1.8). The ship is operated by the PIBC. Built in Finland in 1985, it is 75 meters long and displaces 2,600 tons.

The *Oparin* was designed to support marine biosciences, specifically biomedical marine research. It is one of a few research vessels in the world equipped for this type of research work at sea. The vessel has 14 well-equipped laboratories, diver facilities, and a large decompression chamber. The laboratories are spacious, and deck space is available for mission-related vans. An A-frame on the stern is available for handling oceanographic equipment. The ship is equipped with a vivarium to house rodents used in research experiments. At least one nuclear magnetic resonator is installed on board, and a photo lab is available for real time photographic support. A central computer system provides the ability to process data quickly and send it ashore to the institute by satellite link.

In recent years, the Harbor Branch Oceanographic Institute in the United States has conducted collaborative work with PIBC personnel on board the ship. The PIBC is actively looking for other foreign partners for joint scientific projects. Present funding limitations for the FEB RAS mean that *Oparin* can go to sea as a research ship only a few days a year.

When not involved in research, the ship is sometimes used to transport automobiles from Japan to Vladivostok. In this way, the vessel can be kept operational in the present time of greatly reduced funding support for seagoing research in Russia.

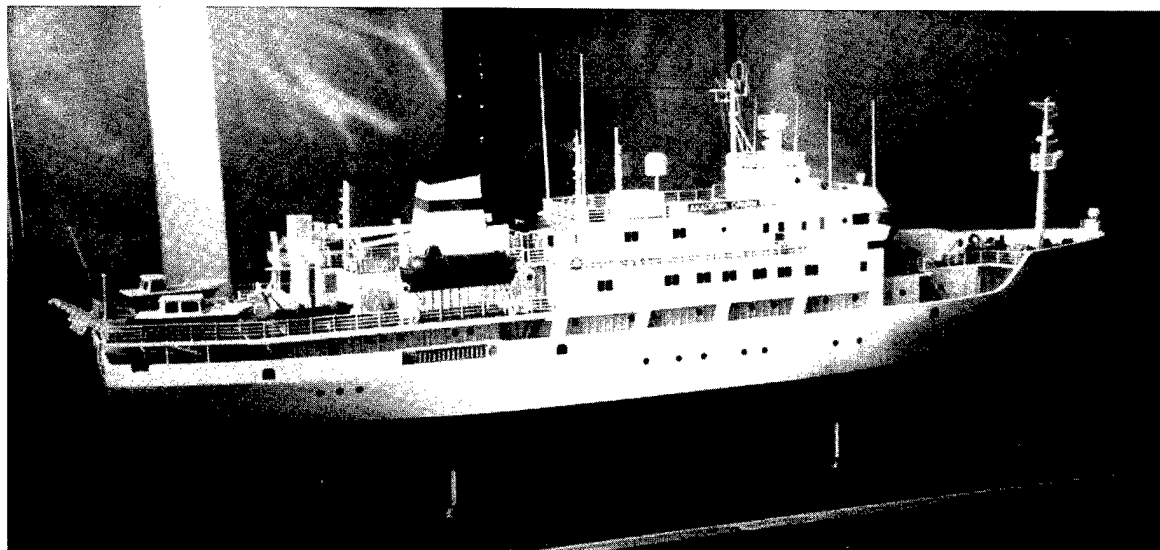


Fig. 1.8. Research Vessel *Academik Oparin*, Pacific Institute for Bioorganic Chemistry. Ship model at Far Eastern State Technical University, Vladivostok.

The Institute of Marine Biology (IMB)

At this site visit, the panel was briefed by Dr. Vitaly G. Tarasov, acting director. The Institute of Marine Biology was founded in 1967. The basic focus for research activities is the near shore coastal areas of the Russian Far East. The goal of the research is the balanced conservative use of the marine resources of the region and the protection of these resources from environmental damage.

The IMB employs 450 people, 300 of whom are research staff. The remaining 140-150 are engineers and technicians. The institute has 20 laboratories, four field stations, and the Far East State Marine Reserve. Two small vessels support coastal projects. Most of the scientists are divers.

Dr. Tarasov said that Peter the Great Bay has the greatest biodiversity in East Asia because this area is influenced both by the warm Kuroshio and cold Oyashio currents. Work is being done to study the effects of dredging in the Kuriles, the impact of past nuclear waste dumping in the Sea of Okhotsk, an assessment of fish stocks in the Bering Sea and the Sea of Okhotsk, and the biofouling of offshore platforms near Sakhalin. In addition, environmental assessment work is being done in the river delta area where North Korea, China, and Manchuria propose to build a major new seaport and railhead.

The institute has also developed cooperative projects with the University of Washington, the University of Alaska, and Hokkaido University. IMB is actively looking for new international cooperative ventures.

Joint Stock Companies Varyag and Dalpribor

During the visit to Varyag, the panel was briefed by Evgeniy N. Leonov, director, and Yuri A. Filchenok, vice president of foreign relations. Varyag was a state-owned factory formed fifteen years ago to produce Navy and merchant marine equipment. The company manufactures short-run specialty products in what would be called a "job shop" in the West. The team visited some of their shop facilities. While the equipment was older, it was well maintained and adequate for this type of production.

Now Varyag is a joint stock company with ownership by both private investors and the government. At present, its major products are consumer goods and medical equipment. Examples of consumer products are telephones, tape players, and a variety of plastic goods.

Even though Russian labor costs are low and labor force skill levels are high, the company is not competitive in the international marketplace. This is mostly due to multi-layered Russian taxes which reduce the price competitiveness of potential export products.

Dalpribor (also a joint stock company) is producing hydroacoustic fish finders, echo sounders, thermos bottles, hair dryers, etc. While the WTEC team did not make a site visit

to Dalpribor, Josif Kanevsky, its technical director, briefed the panel at the time they visited Varyag.

Under the USSR, Dalpribor produced a variety of technical products for the shipbuilding industry. Its present situation is quite similar to that of Varyag. Both companies have lost about 50% of their business since Perestroika. With taxes on their products running as high as 90% of the value of the exports, it is unlikely that these will be viable enterprises for exports from Russia.

Institute for Automation and Control Process (IAPU)

The IAPU was established in 1971 by Academician A. A. Voronov to research control theory, computer science, and mathematical modeling and simulation. The institute presently has a staff of 250 people, including a research staff of 112. This staff includes two academicians, 14 doctors of science, 54 candidates of science, and four corresponding members of the RAS. The director is Academician V. P. Myasnikov.

The six departments of the institute are as follows:

- Expert Design Systems
- Research of Control Processes and Reliability Problems*
- Mathematical Simulation of Complex Systems
- Surface Physics and Design of Semiconductor Systems*
- Development of Non Traditional New Technologies
- Information Support for Ocean Environment Exploration*

*departments visited by the WTEC team

Institute of Chemistry

The Institute of Chemistry was established in 1971 from the chemistry department of the Far Eastern State Technical University. The current staff is 200. In 1991 the staff was 345. The institute comprises 14 laboratories and an engineering technical center. The WTEC team toured four of these laboratories:

- The Laboratory of Inorganic Fluorides performs research and analysis in fluoroplastics for use in the nuclear power industry, making fillers for medical ointments and cosmetics and coatings of metal, low cost fluoroplastic lubricants (trade name, *Forum O*) that has smaller, more uniform particle size than the well-known product *Slick 50*, and fluoropolymer coatings on lithium battery cathodes that double the capacity of lithium batteries. The major contribution of this laboratory is a fluoroplastic powder synthesis process.

- The Laboratory of Sorption Processes produces fluoride glasses which offer special properties when compared to quartz, rare earth ligands that are luminescent, polyethylene films which convert UV to IR for use in greenhouses, a fluoroluminescent method for detecting AIDS in blood, a cleaning filter for sewage cleaning and oil refining, and an absorption material used to clean water of radioactive wastes.
- The Laboratory of Protective Films works on coatings to reduce marine corrosion, coatings of metals to reduce friction, and coatings for cookware.
- The Laboratory of Marine Corrosion has developed a thermoplastic-based antibiofouling paint that is environmentally safe.

NOVOSIBIRSK

The Presidium of the Siberian Branch of the Russian Academy of Sciences (SB RAS)

The study team was hosted by Academician Yuri Shokin, chairman of the Siberian branch. The SB RAS, founded in 1957, is headquartered in the Akademgorodok near Novosibirsk. This branch covers a larger geographic area of Russia than the other two branches of the RAS.

The branch has 12 regional centers and is composed of 74 research institutes and experimental design offices covering the fields of physics, mathematics, and technical, chemical, biological, geological, and social sciences. The branch employs 40,000 people. Among the 9,000 research staff of the Siberian branch are about 55 academicians, 64 corresponding members of the RAS, 700 doctors of science and 5,000 candidates of sciences. Academician Shokin in his remarks mentioned that the branch is experiencing decreasing budgets. He regards the branch as a large research corporation.

Institute of Automation and Electrometry

The Institute of Automation and Electrometry, founded in 1957, has 25 scientific laboratories. The focus of the institute is on lasers, and non-linear physics, new information technologies, and task-oriented computer systems. The institute currently employs 500, including three academicians, 25 doctors of science and 100 candidates for doctors of science. Approximately one half of the institute's funding is derived from international contracts. The institute's work includes materials and device development for short wavelength systems, flight simulators, ferroelectric materials for computer memory storage, mathematical modeling, x-ray tomography, and precision gravimeters.

Institute of Thermophysics

For the past quarter century the Institute of Thermophysics has focused its research on drag reduction and laminar flow of submerged bodies. Methods of drag reduction include injection of gas bubbles into the boundary layer and injection of a fast-made polymer solution into both a plate's turbulent boundary layer and turbulent flow formed inside a pipe. Problems of acoustic radiation by turbulent boundary layer and dynamics of interaction between sound and bubble layers have been studied. A significant number of experiments were conducted in a low turbulent air dynamic wind tunnel followed by field experiments in the Black Sea. The development of cavitation flow and hydroacoustics of wakes are also being studied at the institute.

Lavrentyev Institute of Hydrodynamics (LIH)

The LIH was the first institute founded at the Akademgorodok near Novosibirsk in 1957. The three goals of the LIH were to develop main research directions, to establish active relations with science and industry, and to train young research fellows for advanced science and engineering. Approximately 500 people are employed at LIH under the direction of Academician Vladimir M. Titov. A scientific staff of 170 includes about 135 Ph.D.s, 43 doctors of science, three academicians, and two corresponding members of the RAS.

The institute does fundamental and applied research in the areas of mathematical problems of continuum mechanics and of detonation and explosive processes. The work in applied hydrodynamics includes stratified flow and dynamic flow (turbulence, internal waves, shock, and acoustic wave propagation).

The Detonation and Explosive Processes Laboratory concentrates on applied research in explosive working of materials and high velocity processes (Fig. 1.9). These include explosive hardening, welding compaction, forming of structures from powders, and detonation spraying. Industrial investigations are ongoing with Sweden, Japan, Germany, the United States, and Yugoslavia.

The LIH Applied Hydrodynamics Laboratory efforts include stratified and turbulent flows; wake characteristics; the surface and internal wave generation mechanisms; the effect of waves on submerged bodies; and experimental testing of mathematical models and compilations.

LIH contributions have ranged from the development of innovative solutions to practical problems to pioneering efforts in fundamentals.



Fig. 1.9. Lathe cutting to show successful explosive welding of concentric cylinders of copper and stainless steel (Lavrentyev Institute of Hydrodynamics, Novosibirsk).

Institute of Theoretical and Applied Mechanics (ITAM)

The ITAM was founded in 1957. The staff numbers 600 of whom 35 are professors and 180 are candidates of science. Their focus is on mathematical modeling, aerodynamics, and physical gas dynamics.

The institute has the reputation of being the best institute in the countries of the former Soviet Union in fundamental aerodynamics. The institute has eight wind tunnels of varying sizes and capabilities. One hypersonic wind tunnel uses nitrogen as the working fluid and operates at a Reynolds number of about 10^5 , at altitudes of 80 to 90 km at Mach 16 to 24. All of these wind tunnels are computer controlled. ITAM is collaborating with Princeton University in designing a new generation of wind tunnels.

ITAM scientists are active in international conferences and do much of their work through contracts with companies and academic institutions outside Russia. ITAM has two teaching departments: Novosibirsk State University and Novosibirsk State Technical University. The institute's research directions include aerodynamic research; applied aerodynamic research; hydrodynamic research and cold gas dynamic spraying of metals on glass, on other metals, and on ceramics; solid rocket motors; and self-forging projectiles. This institute is very competitive and is moving toward funding economic self-sufficiency.

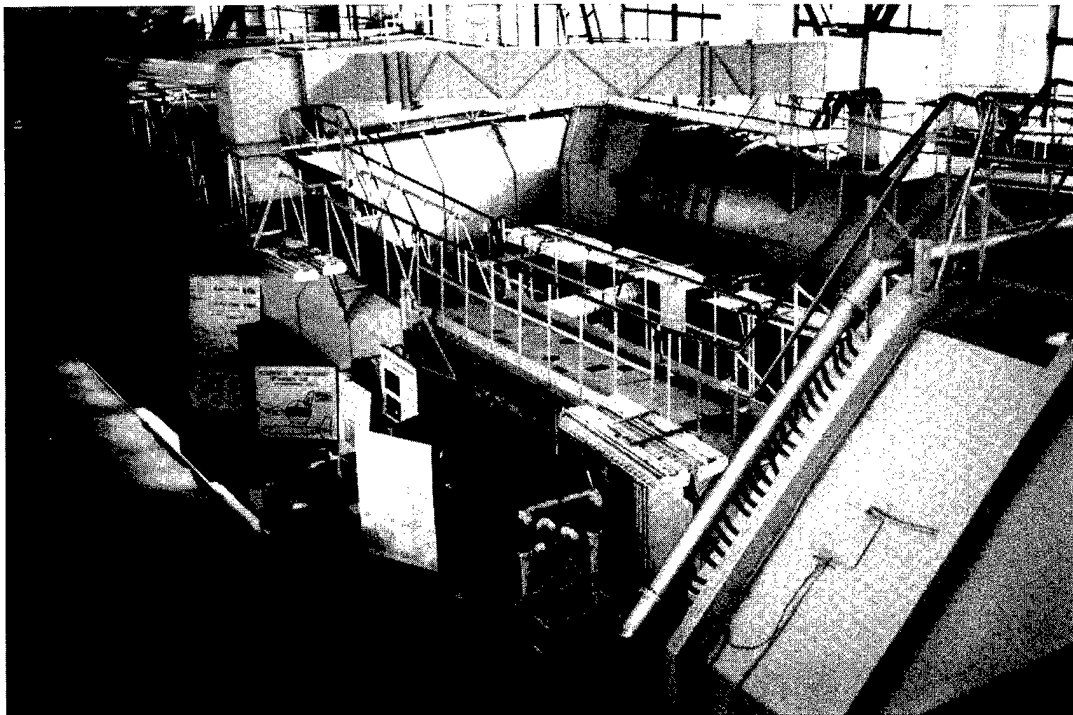


Fig. 1.10. Large wind tunnel: physics of laminar/turbulent transition (Institute of Theoretical and Applied Mechanics, Novosibirsk).

Institute of Computational Technologies

This institute has a staff of 120 people working in 10 laboratories. Their applied work activities have almost stopped. They are now adapting their developed software to other applications.

The major departments of this institute are as follows:

- The Department of Natural Phenomena Processes, which has five laboratories: Aerodynamics, Atmospheric Modeling, Satellite Data Processing, Interval Analysis, and Numerical Analysis

- The Department of Mechanics and Continuous Media, which comprises three laboratories: Computational Hydrodynamics (turbulence in ships' wakes), Aerodynamics (internal flow of turbines), and Plasma Physics
- The Department of Informational Technologies, which provides a communication network, data banks, and data analysis in support of all of the institutes at the Akademgorodok.

SUMMARY

The General Condition of Russian Science and Supporting Facilities

Most, if not all, the entities visited during this study trip are suffering from reduced government funding and downsizing. All, to varying degrees, are seeking alternative and innovative funding sources. Success in this process is evident in that, for the most part, personnel cuts lag behind state funding cuts by 10% to 20%. To a large extent, the institutes have shifted from being organizations totally supported by the Russian Academy of Sciences, in the past, to becoming business ventures planning for the future. However, this process is slow and uncertain, and there has been a migration of highly trained people away from science to the world of business. This is particularly true for computer support personnel, many of whom have moved into banking.

The High Technologies Association (HTA), a public entity, was founded in Vladivostok in mid-1994 to assist young researchers in trying to start high technology businesses. The HTA was established to give researchers specific how-to-do-it help in business management, advertising, marketing, and legal matters. The HTA is supported by USAID grants. At present, 12 small companies have joined HTA.

One tangible measure of the success of the WTEC panel's visit to the Far Eastern and Siberian branches of the Russian Academy of Sciences is the 29 proposals received from Russia by the Office of Naval Research since our visit to those areas. They are listed in Appendix B. Those proposals funded by ONR will provide a basis for U.S.-Russian cooperative scientific and technical projects.

CHAPTER 2

SITE REPORTS

Site: *Akademik Oparin* (Research Vessel)
c/o Pacific Institute of Bioorganic Chemistry
(PIBC)
Far East Branch, Russian Academy of Sciences
17 Palchevsky Street
Vladivostok, 690041, Russia
Phone: (4232) 311635, 311430
Fax: (4232) 310900

Date Visited: October 27, 1995

WTEC Attendees:

D. Walsh (report author), H. B. Ali, R. Blidberg, S. Chechin, M. J. DeHaemer, L. Gentry,
J. Moniz, J. B. Mooney

Hosts:

Dr. Valery A. Rasskazov, Deputy Director, PIBC
Natalie M. Shepetova, Assistant Director for Foreign Relations, PIBC
Captain Vladimir Goluak, Master *Akademik Oparin*

(plus several staff members who conducted a tour through the ship for the team)

BACKGROUND

This site report is about a research platform rather than an institute, laboratory, or company. However, it is useful to produce this information as a site report since the *Akademik Oparin* represents a unique, well-equipped research vessel that is available for joint expeditions or outright charter at day rates that are hard to match anywhere in the world. Information on other vessels is included in the FEB RAS site report.

The WTEC team visited the *Oparin* late in the afternoon of its last day in Vladivostok. Just prior to this visit, the team had been taken on an orientation tour of Vladivostok port's inner harbor (the "Golden Horn") on board a boat belonging to the Institute of Marine Technology Problems. Academician Ageev was the host and guide. At the completion of the tour, the boat was brought alongside the *Oparin* at a dock area where most of the research fleet of the Far Eastern Branch of the Russian Academy of Sciences was docked.

The team's tour of the ship was very impressive. The vessel was built in Finland by Hollming in 1985. It was especially designed to conduct biochemical and bioorganic research at sea and is one of only two known ships in the world dedicated to this type of research. The other, larger vessel is operated by the Japanese. The vessel also has a wide array of analytical instrumentation and equipment including an electron microscope. According to PIBC director, Academician G. Elyakov, the ship is as well equipped as any of his laboratories at the institute.

The condition of the vessel appeared to be quite good considering that it has not operated very much in the past four years. Its last extended scientific cruise was in 1991, although the PIBC does try to make at least one 30-day scientific cruise a year. Previously, long cruises were taken to the waters around Australia, in the Indian Ocean, and in the Eastern Pacific.

A detailed brochure on the *Akademik Oparin* is appended to this site report. It gives specific information on the vessel and its characteristics.

RESEARCH & DEVELOPMENT

The visit to the 75-meter long *Oparin* consisted of a thorough tour of the ship's 14 laboratories; diver facilities, including a large decompression chamber; bridge area; and topside spaces. After the tour, a farewell dinner party was given in the ship's mess area. In addition to the WTEC team, approximately 10 other persons were in the party. They were from the PIBC, Institute of Marine Technology Problems (IMTP), and the Far Eastern Branch of the Russian Academy of Sciences (FEB RAS).

The ship is primarily designed to support marine biosciences. The somewhat specialized on-board laboratories have the necessary instrumentation and analytical equipment needed to support this kind of work. However, the laboratories are fairly spacious, and they could be adapted to other kinds of oceanographic research with a minimum of mobilization time. In addition, there is topside space for putting specialized, mission-related vans on board where the added equipment might not fit in one of the laboratories. An A-frame on the stern permits the handling of oceanographic equipment to depths of 500 meters.

To support on-board research projects and to provide autonomy for long-duration cruises, there are a variety of specialized facilities available. For example, there is a fairly large

vivarium to hold mice, rats, and other small animals used in research experiments. A glass blowing shop is available to make and repair laboratory glassware. The photo lab provides real-time photographic support for the scientific staff.

Oparin also has a very complete facility for supporting divers. There is a fully equipped diving locker, a high-pressure air compressor for charging scuba tanks, and a large, double lock decompression chamber. The compartment where the chamber is located is equipped with sleeping facilities to permit chamber operations around the clock if required. This diving facility was designed into the ship, recognizing the *in situ* collection of specimens could be best done by divers. Several PIBC personnel, including scientists, are qualified divers. Diving is restricted to a maximum depth of 40 meters.

A central computer system provides the ability to process data quickly. Academician Elyakov said that often data would be sent to the institute from the ship by satellite link. This permitted scientists at the institute, on a real time basis, to participate in and back up the work being done at sea.

COMMERCIAL ACTIVITIES

One way several of the research ships belonging to the FEB RAS can generate income is to be leased for commercial purposes. For example, the WTEC team saw the 6,900 ton *Akademik Korolev* at the passenger ship terminal in Vladivostok. It is now being used to haul passengers. The *Akademik Oparin* makes occasional charter trips to Japan, where the charterers buy consumer goods and used cars for import into Russia.

Although the purist might criticize such uses for multimillion-dollar, unique research vessels, FEB RAS must often choose between doing nothing in scientific trips or doing something in charters unrelated to the ship's basic mission. In the former case, the vessel will lie alongside a dock, where it may or may not get needed upkeep maintenance. In the latter, the vessel operates, machinery is maintained, and the crew is kept intact. The right decision is to operate the vessel in any way possible to keep it in operating condition.

The preference of PIBC is to conduct joint scientific programs, where the research activities would benefit both the institute and the visiting researchers. The second choice would be to charter the ship with crew, technicians, and on-board laboratory equipment to another user who would employ it for research. At the dinner party, it was indicated that the rate for the 2,600 ton *Akademik Oparin* would be about \$2,500 a day. This would be inclusive of crew, technicians, food, fuel, and laboratory consumables. An equivalent vessel in the United States would run from \$12,000 to \$16,000 a day.

SUMMARY

This ship is well-equipped and well-maintained. It manages to get some operational time either for commercial business charters or in limited support of the research programs of the PIBC, which has operational control over the vessel.

The *Akademik Oparin* would be an excellent bargain for any of Russia's neighboring states in the Far East, where an additional ship platform might be needed on a temporary basis. And for scientific work proposed to be done by foreign scientists inside Russia's territorial waters or in its 200-mile-wide Exclusive Economic Zone, the usual nine-month wait to get research vessel clearances for foreign ships would disappear if the *Oparin* were used instead.

REFERENCES

2600 T Biological Research Vessel. Illustrated color brochure produced by Hollming, Ltd. of Finland. In Russian and English. Provides detailed information on the *Akademic Oparin*.

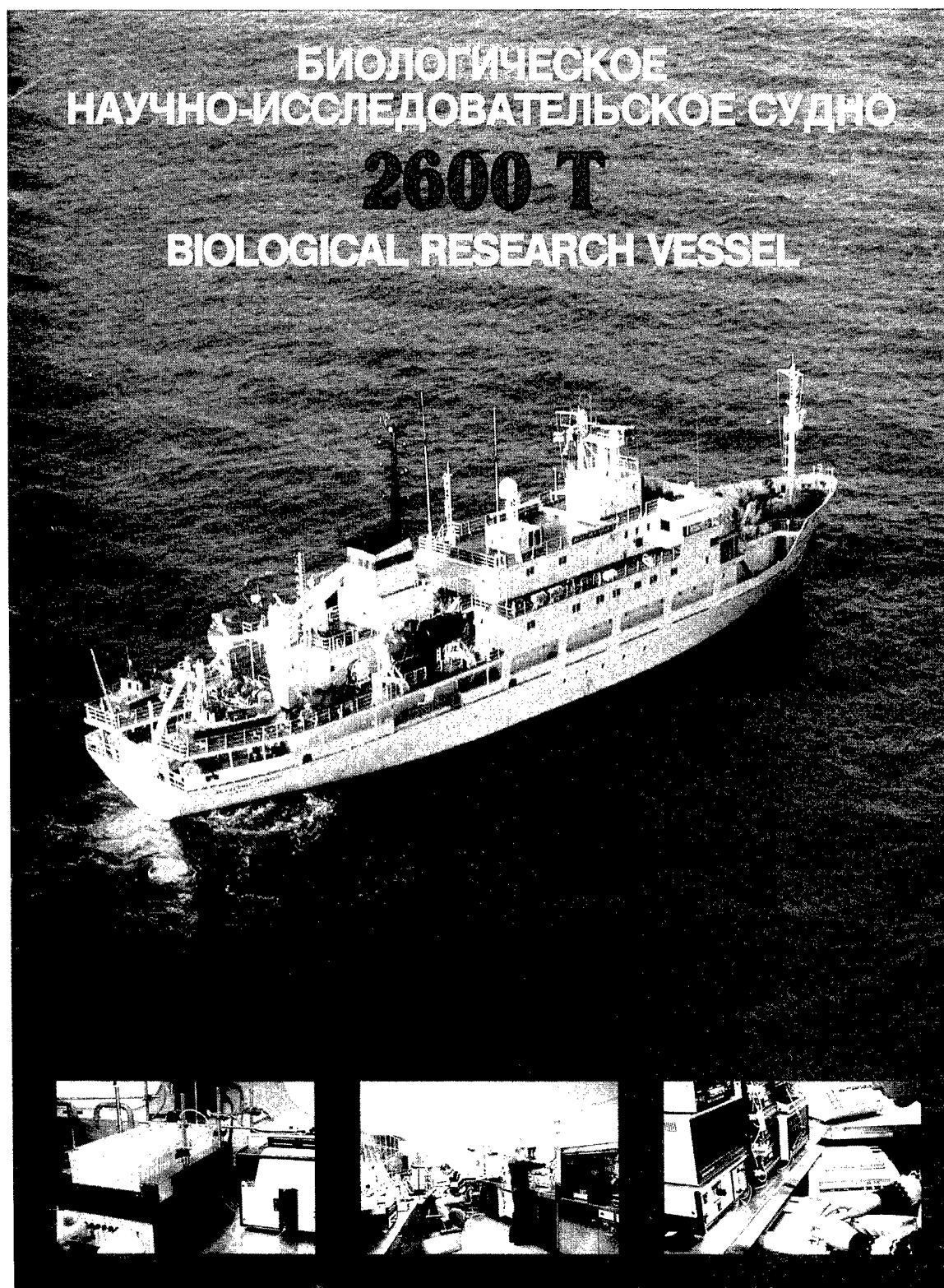
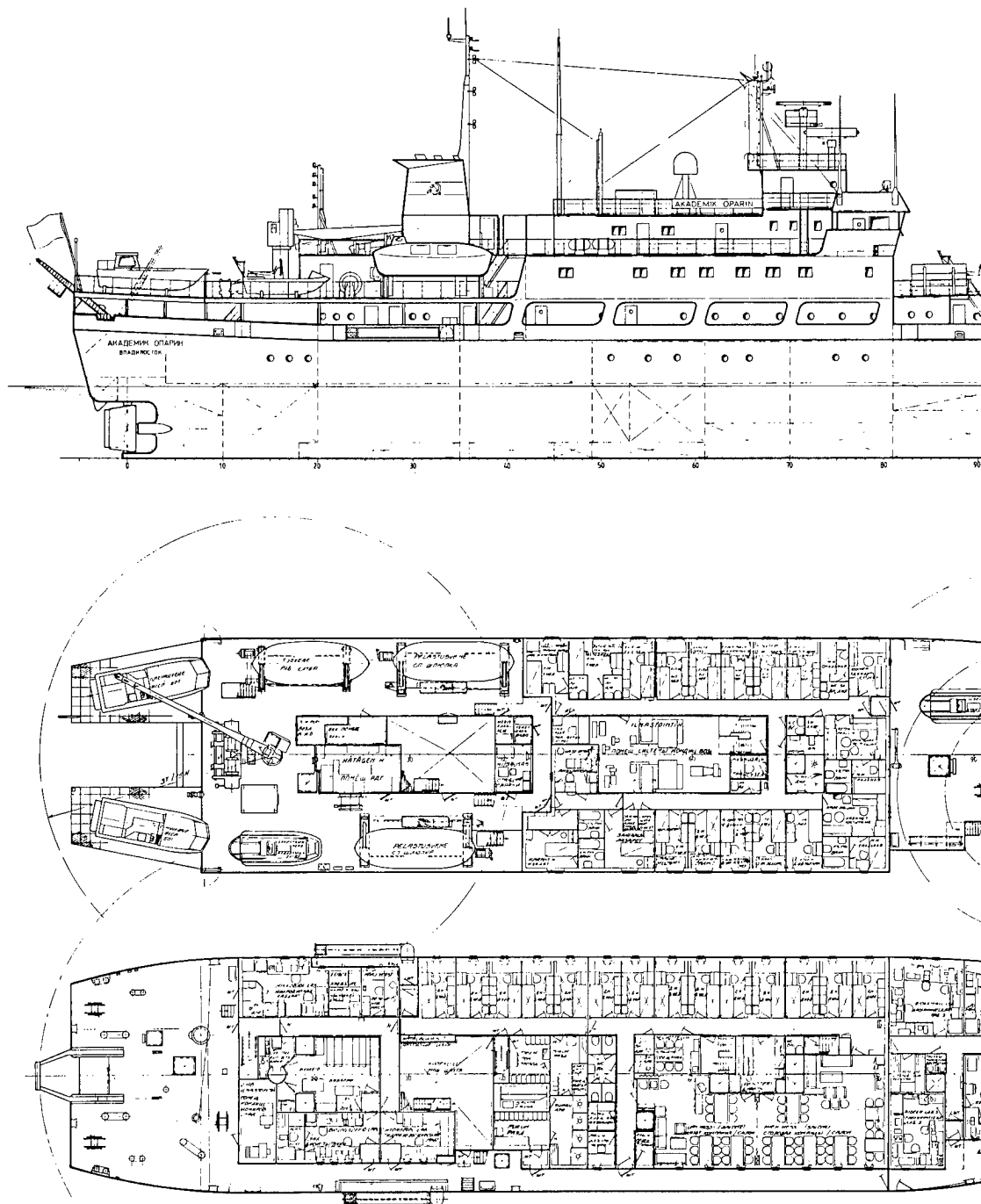
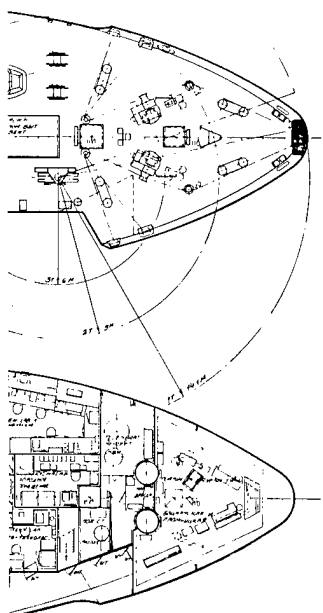
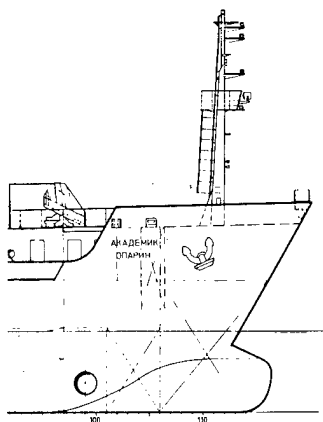


Fig. 2.1. *Oparin* brochure, cover.

Fig. 2.2. *Oparin* brochure, p. 1.

т/х "Академик Опарин",
построенный на верфи А/О
Холлминг для Академии наук
СССР по заказу В/О "Судоимпорт"
(стр. № 0254)

M/S "AKADEMIK OPARIN"
Built for the USSR Academy of
Sciences by Hollming Ltd. Shipyard
(Yard No. 0254) on the order of
V/O Sudoimport.



Судно предназначено для проведения химических и биохимических исследований морских организмов Мирового океана с целью поиска, выделения и исследования структуры и физиологической активности соединений, обладающих антибиотическим, противоопухолевым и иммуностимулирующим действием. Для выполнения этих функций судно оснащено необходимыми помещениями и оборудованием для отбора проб водолазами и тралением, для химических, биохимических, физико-химических, микробиологических и биологических исследований. Исследовательское оборудование включает в себя разработанную фирмой "А/О Холлминг-Электроника" интегрированную научную систему, состоящую из ЭВМ, измерительного и аналитического оборудования, подключенных между собой через локальную сеть, а также из программ сбора и обработки данных.

Судно спроектировано и построено по правилам Регистра СССР для неограниченного района плавания с символом КМ ⊕ Л1 ⊠ А2 (научно-исследовательское судно).

При строительстве особое внимание обращено на уменьшение уровня вибрации и шума, а при проектировании корпуса стремились получить оптимальные обводы для улучшения мореходных качеств судна.

The vessel is designed to conduct chemical and biochemical experiments and for research work on ocean organisms. The purpose of the research is to find, separate and examine the structure and functions of those physiologically active compounds that are antibiotic, cancer-preventing or immunity-improving.

For carrying out these tasks, the ship is equipped with spaces and equipment for sampling by means of diving and trawling and for carrying out chemical, biochemical, physical-chemical, microbiological and biological research work.

In addition, the research equipment includes an integrated scientific system developed by Hollming Ltd. Electronics. This integrated scientific system consists of computers and measuring & analyzing equipment, which are connected to each other through the local area network, plus the data acquisition and data processing software.

The ship has been designed and built in conformity with the class requirements for unrestricted service of the USSR Register of Shipping to have class notation: KM⊕L1⊠A2 (research vessel).

During construction, special attention was paid to vibration- and noise-reduction and to designing the hull for good seafaring characteristics.

Главные размерения:

Длина наибольшая	75.5 м
Ширина по шпангоутам	14.7 м
Высота борта до главной палубы	7.3 м
Осадка, проектная	4.5 м
Дедвейт при осадке 4.5 м	ок. 880 т
Скорость при проектной осадке	15,2 узла

Main particulars

Length o. a.	75.5 m
Breadth, mid	14.7 m
Depth to main deck	7.3 m
Draught, design	4.5 m
Deadweight at 4.5 m	abt 860 t
Speed at design draught	15.2 knots

Fig. 2.3. Oparin brochure, p. 2.

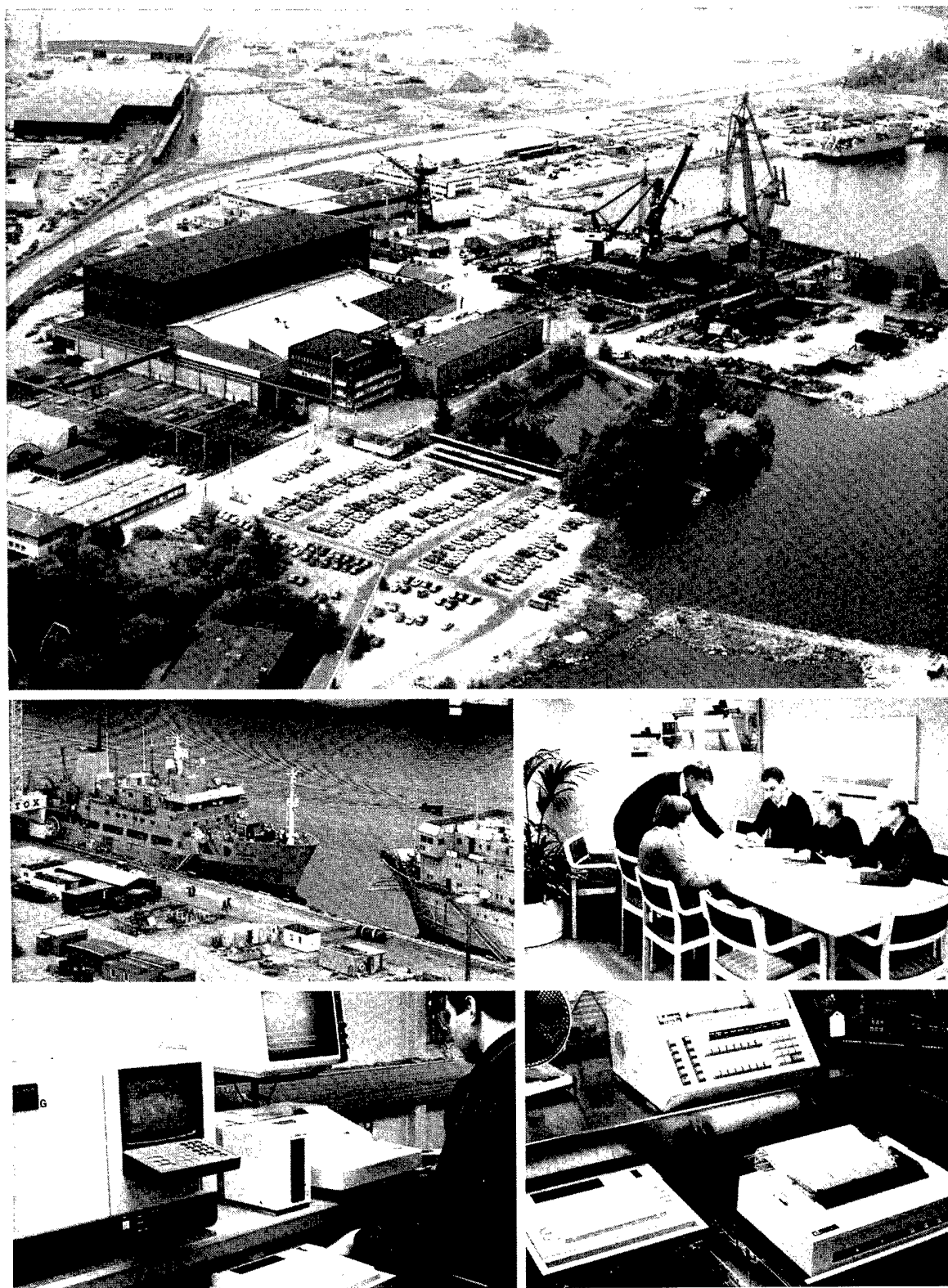
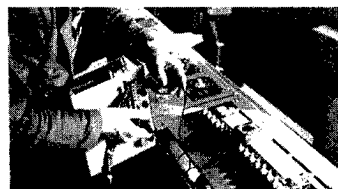
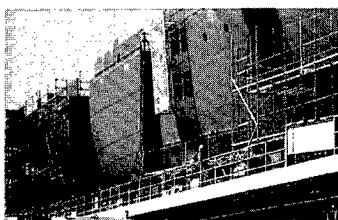


Fig. 2.4. *Oparin* brochure, p. 3.



Проектирование судна выполнено в конструкторском бюро верфи совместно с отделом морских исследований в сотрудничестве со многими советскими организациями: Отделом морских экспедиционных работ (ОМЭР) Академии Наук СССР, Тихоокеанским институтом биоорганической химии ДВНЦ АН СССР, Ленинградским центральным проектно-конструкторским бюро, Регистром СССР.

Сборка судна происходила на стапеле из насыщенных секций: трубопроводы, фундаменты механизмов, кабели, иллюминаторы были установлены в секции до их подъема на стапель. Основная часть систем судна была предварительно собрана в модули, которые потом были установлены в корпусные секции. Окончательной стадией строительства являлось проведение многосторонней программы испытаний.

С целью повышения уровня автоматизации научно-исследовательской работы на судне установлена интегрированная научная система, которая основывается на специальной локальной сети NETOS 625, разработанной "А/О Холлминг-Электроника".

В интегрированной научной системе наиболее важные лабораторные анализаторы, интегрированная навигационная система, гидрографический эхолот и система главных ЭВМ подключены между собой через локальную сеть. Соединения выполнены специальными интерфейсными блоками подключения к сети, которые оснащены многосторонним программным обеспечением для сбора и передачи данных.

The design of the ship was carried out by both the shipyard's Design Department and the Ocean Systems Department in co-operation with several USSR organizations, e.g. the Department of the Marine Expedition Works and the Institute for Bio-organic Chemistry of the Pacific Ocean of the U.S.S.R. Academy of Sciences, Leningrad Central Design Bureau and Inspectorates of USSR Register of Shipping, in order to ensure agreement upon the plans of the project.

The hull of the vessel was assembled on the building berth from sections which had been fitted with piping, foundations of machinery, cable layers, windows etc. prior to their lifting onto the berth. The majority of the systems onboard were prefabricated into modules which were lifted into the hull sections. The construction project was completed by an extensive testing and trial programme.

In order to raise the degree of automation of the research work, there is an integrated scientific system onboard the vessel. The integration is based on a special local area network called NETOS 625, developed by Hollming Ltd. Electronics.

In this integrated scientific system the most important laboratory analyzers, integrated navigation system, hydrographic echo-sounder and the main computer system are connected to each other through the local area network. Connections are realized with special network interface units provided with versatile data-acquisition and data communication software.

Fig. 2.5. *Oparin* brochure, p. 4.



Fig. 2.6. *Oparin* brochure, p. 5.



Главный вычислительный центр (1, 2) находится на твиндеке посередине судна с тем, чтобы уменьшить влияние качки судна на аппаратуру ВЦ.

Система главных ЭВМ снабжена множеством современных периферийных устройств (3), программным обеспечением автоматического сбора (4) и регистрации данных, а также различными научными пакетами программ, подходящими для последующей обработки данных измерений (5).

Для выполнения научных исследований на судне имеется более десяти полностью оборудованных лабораторий.

В размещенной на главной палубе в носу химико-технологической лаборатории (6) имеется оборудование для выделения физиологически активных соединений из морских организмов.

Для выделения и исследования химического строения веществ на судне предусмотрены три биохимических лабораторий (8, 10), а также спектроскопическая (9) и физико-химическая (7) лаборатории. В них установлено большое количество научных приборов, в частности, несколько жидкостных и газовых хроматографов (11, 12), IR- (13), УФ-видимых и флуоресцентных (14) спектрофотометров, аминокислотных и углеводных анализаторов (15), а также газовый хроматограф/масс-спектрометр (16).

Для разборки, разделки, фиксации и идентификации биологического материала имеется гидробиологическая лаборатория.

Для работы с культурами тканей и проведения микробиологических испытаний предусмотрены лаборатория и бокс биоиспытаний, микробиологическая лаборатория с ламинарным боксом (17).

The main computer system (1, 2) is installed on the tween deck close to the centre of motion of the vessel, so as to be minimally affected by the ship's movements whilst at sea.

The main computer system is equipped with numerous up-to-date peripheral devices (3), automatic data acquisition (4) and archiving programs, and scientific program packages for measurement data postprocessing (5).

The scientific work onboard the vessel is carried out in more than ten fully-equipped laboratories.

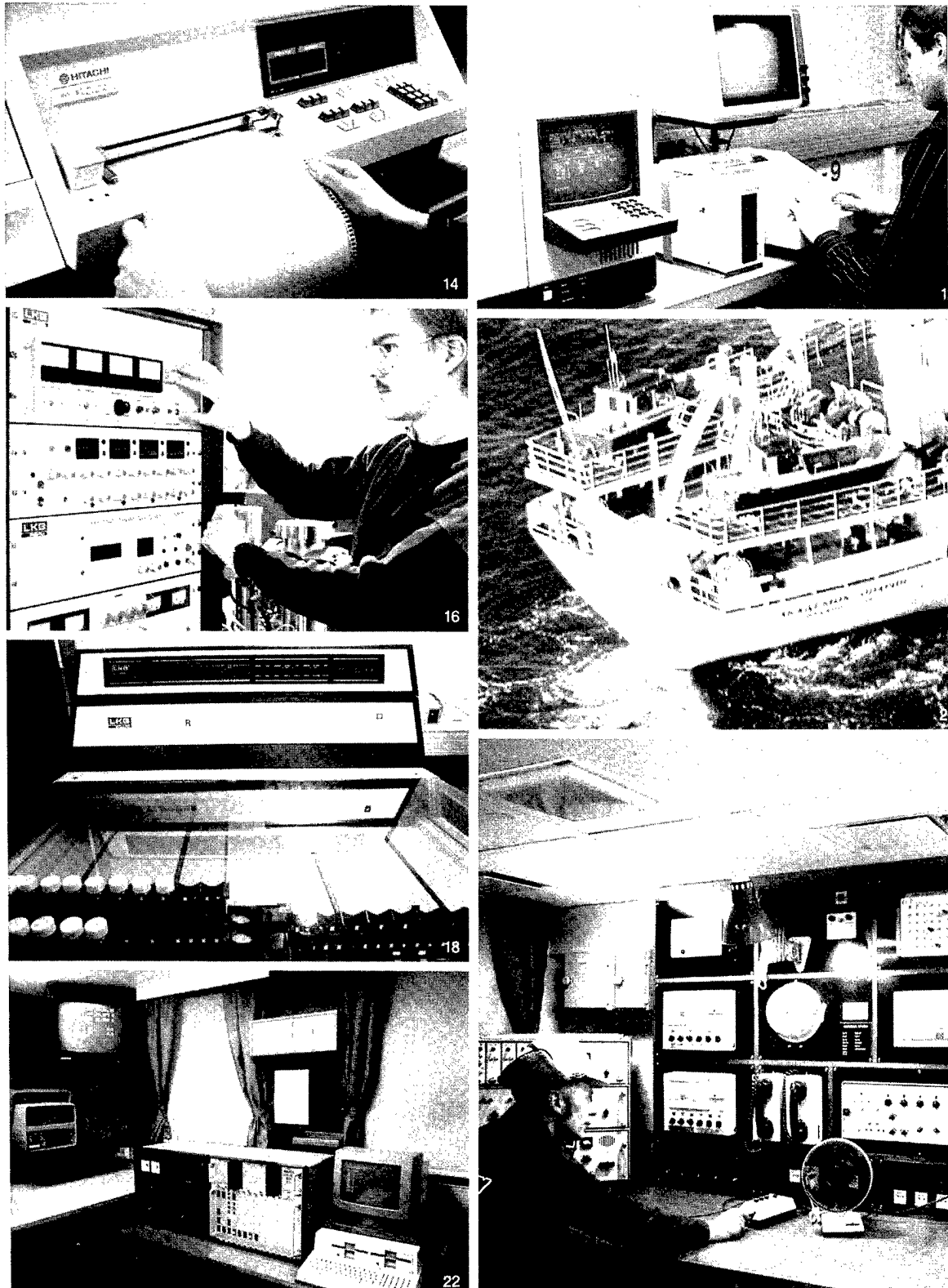
The Laboratory for Chemical Technology (6), located on the forepart of the main deck, is intended for separation of physiologically active compounds from sea organisms and their preparation.

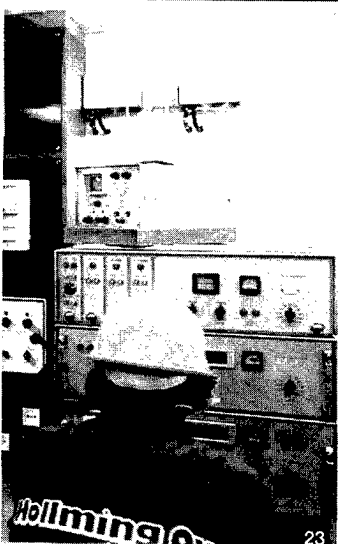
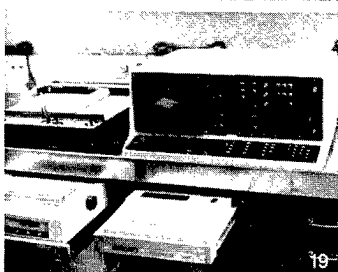
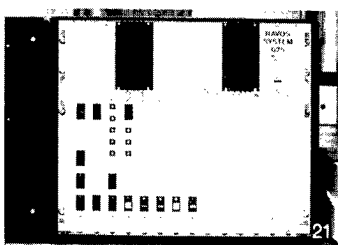
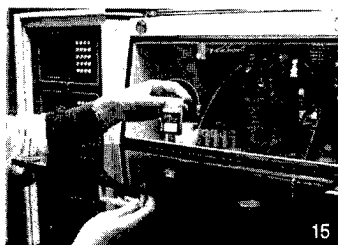
For the separation and investigation of the chemical structure of the samples there are three Biochemical Laboratories (8, 10), a Spectroscopic Laboratory (9) and a Laboratory for Physical Chemistry (7). Their extremely wide spectrum of scientific instruments includes several Liquid and Gas Chromatographs (11, 12), IR- (13), UV- Vis- and Fluorescence (14) Spectrophotometers, Amino Acid and Carbon Hydrate Analyzers (15) and a Gas Chromatograph/Mass-Spectrometer system (16).

For the separation, preservation and identification of biological materials there is a Hydrobiological Laboratory.

The handling of tissue cultures and microbiological experiments are carried out in the Laboratories and Chambers for Biological Experiments and Microbiology (17).

Fig. 2.7. *Oparin* brochure, p. 6.

Fig. 2.8. *Oparin* brochure, p. 7.



В расположенной на палубе ходового мостика лаборатории биосинтеза установлены, в частности, жидкостный сцинтилляционный счетчик (18) и программируемый многоканальный анализатор (19) для изучения механизмов биосинтеза с помощью радиоактивных веществ.

Кроме лабораторий, на судне имеется много вспомогательных научных помещений: стекловарная мастерская, виварий и фотолаборатория. На судне также установлены холодильные камеры, где обеспечено хранение биологического материала при температуре ниже -45°C .

Для сбора биологического материала с глубин до 500 м и для других исследовательских работ на судне установлены 2-барабанный исследовательская лебедка, П-рама. Помимо того, на судне предусмотрены пять различных рабочих катеров (20), помещения и полные комплекты снаряжения для водолазов, система рыбопоискового сонара и эхолотов.

Судно оборудовано интегрированной навигационной системой NAVOS 625 (21, 22), разработанной "А/О Холлминг-Электроника". Отдельные навигационные устройства, как-то: приемник спутниковой навигации, Лоран-С, Омега, Допплеровский лаг, гирокомпас и автопилот подключены к ЭВМ навигации. Система NAVOS 625 определяет точное местоположение судна и способна осуществлять управление судном вдоль программированной исследовательской линии.

Радиостанция (23) укомплектована в основном приборами, изготовленными в СССР: передатчиками, приемниками, аварийными комплексами, УКВ-радиотелефонами и телетайпом.

The Biosynthesis Laboratory, on the wheelhouse deck, is equipped with a Liquid Scintillation Counter (18) and Programmable Multichannel Analyzer (19) to study the effects of the physiologically active compounds on the biosynthetic mechanisms with radioactive tracer elements. In addition to the laboratories, there are well-equipped scientific premises such as a Vivarium, a Glassblowing Workshop and a Photo Laboratory. There are also refrigerated chambers, where large amounts of biological material may be stored at temperatures below -45°C .

For sample-gathering down to a depth of 500 m and for other research activities to be done outside the vessel, she is furnished with a hydraulic dualdrum winch, and an A-frame.

Furthermore, the vessel contains five different work boats (20), premises and a complete set of equipment for several scuba divers, plus fish finding sonar and echo-sounder systems.

The vessel is equipped with an integrated navigation system NAVOS 625 (21, 22), developed by Hollminger Ltd. Electronics. Several navigation devices such as the Satellite navigator, Loran-C, Omega, Doppler Log, Gyro Compass and Autopilot have been connected to the navigation computer. NAVOS 625 calculates the accurate position of the vessel and it can, for example, steer the vessel along a pre-programmed research line.

The radio station (23) is built mainly of Soviet-made equipment, having transceivers both for normal and emergency traffic, VHF radio telephones and a telex station.

Fig. 2.9. Oparin brochure, p. 8.

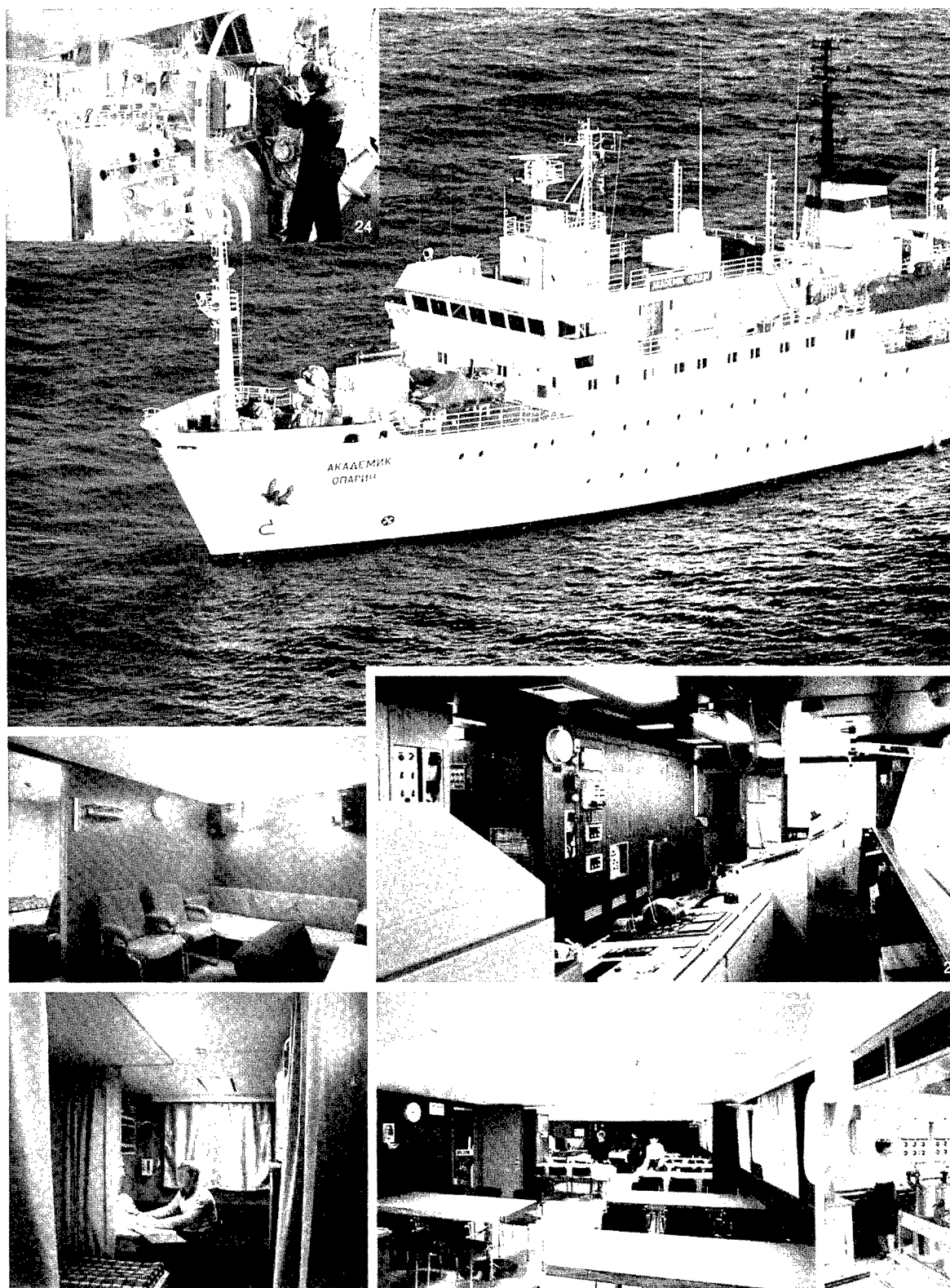
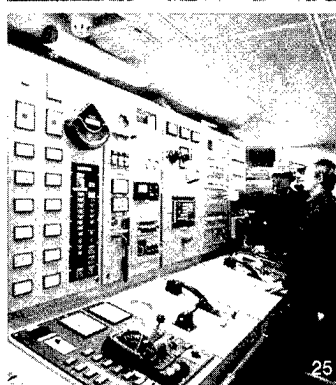
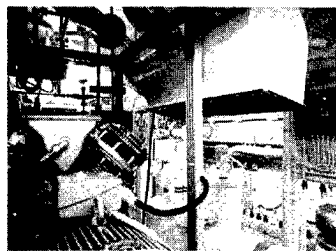


Fig. 2.10. *Oparin* brochure, p. 9.



В качестве главного двигателя (24) установлен среднеоборотный дизельмотор советского производства, работающий через редуктор на ВРШ. ВРШ оборудован поворотной насадкой. С целью улучшения управляемости судна дополнительно установлено носовое подруливающее устройство.

Для выработки электроэнергии на судне установлены 3 дизельгенератора и валогенератор. Судно оборудовано специальной системой беспереывного питания (NO-BREAK) в целях обеспечения стабильного и длительного электропитания лабораторного оборудования и ЭВМ. Машинное отделение оснащено эффективной системой аварийно-предупредительной сигнализации (25).

Дополнительно к интегрированной навигационной системе судно укомплектовано обычными навигационными приборами: двумя радиолокаторами, лагом, эхолотом, радиопеленгатором, приемником индикатором и т. д. (26).

На судне предусмотрены места на 69 чел.

На судне 43 каюты, из них 4 блок-каюты (27), 13 одноместных кают (28) (5 кают оборудованы койкой типа "Пульман") и 26 двухместных кают.

Судно оборудовано столовыми (29) на 52 чел., предусмотрена возможность их разделения с помощью раздвижной двери. Имеется возможность соединить конференц-зал на 6 чел. с каюткомпанией. Камбуз (30) расположен непосредственно под столовыми вблизи от провизионных камер.

The ship is powered by a medium-speed diesel engine (24) coupled through a reduction gear to a CPP running in a steerable nozzle. Stability and good manoeuvrability are improved still more by a bowthruster.

The electrical power onboard is produced by three diesel generators and one shaft generator. A special "no-break" system is provided to ensure the stable and continuous powering of laboratory equipment and computers.

An efficient monitoring and alarm system has been provided for the entire machinery plant (25).

The navigation system is completed by ordinary ship navigational instruments: two radars, log, echo-sounder, RDF and navigator, etc. (26).

The vessel accommodates 69 persons. Onboard the vessel there are 43 cabins in all, consisting of 4 apartments (27), 13 single cabins (28) (of which 6 contain an additional "pullman-bed") and 26 twin-bed cabins.

The two messrooms (29) are designed for a total of 52 persons. These messrooms can be separated or combined by means of a sliding wall. By the same means, the conference room for 6 persons can be combined with the officers' mess. The galley (30) is located just below the messrooms and close to the provision stores.

Fig. 2.11. *Oparin* brochure, p. 10.

Site:

Dalpribor
46/50 Borodinskaya Street
Vladivostok, 690105, Russia
Phone: (4232) 326312
Fax: (4232) 326307

Date Visited:

October 23, 1995

WTEC Attendees:

D. Walsh (report author), H. B. Ali, R. Blidberg, S. Chechin, M. J. DeHaemer, L. Gentry, J. Moniz, J. B. Mooney

Host:

Iosif N. Kanevsky, Technical Director, Dalpribor

BACKGROUND

This is not really a "site report." The WTEC team was scheduled to visit Dalpribor, but on arrival at Vladivostok, we found that this visit had been canceled. However, Mr. Kanevsky joined the meeting at Varyag and gave us a brief talk on what his company does.

This report on Dalpribor is based only on about 30 minutes of briefing by Mr. Kanevsky. The team received no printed materials or other information about this company.

Before Perestroika (1989) the company employed 4,500 people, now it has 1,700 people. The basic business of the company was building hydroacoustic devices (e.g., echo sounders, sonars, etc.) for the Navy and for fishing and merchant ships. At one time, the company was the largest supplier of such equipment for all newly built ships in the Soviet Union. Today, there is no more military business since companies in European Russia can supply the limited Navy requirements. Civil shipbuilding is greatly reduced and the demand for fish-finding sonars is down as well. The last order was a year ago for 15 ship sets.

RESEARCH AND DEVELOPMENT ACTIVITIES

Considering their past business building hydroacoustic devices, it is assumed that Dalpribor has had some in-house R&D capabilities. However, this issue was not specifically discussed by Mr. Kanevsky, and the company may simply build to designs developed by research institutes.

COMMERCIAL ACTIVITIES

The product lines currently available from Dalpribor are as follows:

- Fish-finding sonars
- Echo sounders
- Hydroacoustic control systems for fish trawl nets to optimize the catch by net positioning
- Thermos bottles
- Hot pots for liquids
- Electric mixers
- Hair dryers
- Electric drills
- Thermostats
- Plastic mugs, bowls, etc.

In addition to specific consumer products, the company can also weld titanium and do various kinds of metal work. It has also been making molding forms for plastics manufacturing.

SUMMARY

Dalpribor is finding itself in the middle of a very difficult defense conversion process. Staff has been greatly reduced, and the company's traditional product lines are no longer in demand. By shifting to consumer products they are probably going in the right direction because there is considerable consumer demand in Russia for quality household goods. In developing products for the domestic market, the company can also get the experience it needs to produce quality goods at attractive prices for export. However, Dalpribor is having the same problem with excessive taxation as Varyag, and until this basic obstruction is removed, it is doubtful the company can be competitive in the international marketplace.

Site:

**Far Eastern State Technical University
(FESTU)
10, Pushinskaya Str.
Vladivostok, 690600, Russia
Phone: (4232) 265118
Fax: (4232) 266988**

Date Visited:

October 24, 1995

WTEC Attendees:

M. J. DeHaemer (report author), H. B. Ali, R. Blidberg, S. Chechin, L. Gentry, J. Moniz, J.B. Mooney, D. Walsh

Hosts:

Prof. Gennady P. Turmov, President, FESTU; Academician

Email: root@dpicnit.marine.su

Vladimir I. Korochentsev, Manager, Sonic Faculty; Director of Design Office "Dalnee"

BACKGROUND

In recognition of its status as an important technical university, the Far Eastern Polytechnical Institute (founded 1899) was renamed the Far Eastern State Technical University (FESTU) by decree of the Russian Federation Government in December 1992. FESTU, in Vladivostok, has approximately 10,000 students and four branch campuses. It is comparable in size to two other state universities in the Russian Far East at Komsomolsk-on-Amur and at Khabarovsk. Overall, FESTU was said to rank in the top 100 Russian universities.

The FESTU faculty of 700 includes three members of the Russian Academy of Sciences, 100 doctors of science and 400 candidates for doctor of science. Among the eighteen major departments are the disciplines of electrical engineering, radio and instrumentation, natural sciences, architecture, naval engineering, economics and management, mechanical engineering, heat and power engineering, and the humanities. A six-year program is offered for a bachelor's diploma degree in naval engineering. Ph.D. programs are offered in ocean science and ship construction and other fields in technology, economics, math, and philosophy. The humanities program emphasizes technical language understanding in English, Chinese, Japanese, and Korean.

Although FESTU and the city of Vladivostok were closed to foreigners as recently as three years ago, the university is pursuing international cooperation in the development of

technical engineering education and research. Approximately three dozen students from Washington State University are enrolled.

TECHNOLOGY AND RESEARCH PROGRAMS

Prof. Turmov, the FESTU president, personally conducted the WTEC group through the areas he felt were related to work in marine technologies. He explained that FESTU's research programs were funded to an annual level of about 1.5 billion rubles (\$330K), principally from the federal government, with some support from local government and private industry. In a tour of the university museum, he pointed out exhibits and memorabilia that showed FESTU's historical connection to ship construction and design, including the first development of welding of ships and bridges in Russia.

As a result of a technology agreement with Japan, FESTU has received \$30 million of industrial machine tools to support three education centers: advanced technology, metal working, and wood working. Several CNC automated machines were shown as well as computer controlled machines for laser cutting of sheet steel. Machine nameplates were Niigata, Mori-Seiki, Nihon-Kikai, and Makino. A challenging student project of fabricating a four-blade propeller from aluminum stock was in progress.

A Computer-Aided Design (CAD) laboratory was well equipped with IBM 486 PCs and appropriate peripherals.

Four exhibits were set up for the benefit of the WTEC group. Two exhibits demonstrated the ROV program at FESTU. The third and fourth exhibits were poster sessions on using optical fiber as a sensor for ocean tomography and on using artificial neural networks to interpret sensor data.

V. I. Korochentsev, director of the design office "Dalnee," introduced the ROV exhibits, stating that 39 ROVs and tethered vehicles had been designed by FESTU and the design office. The characteristics of 10 of the vehicles are described in Table 2.1.

The ROV *Roby* was reported to have been the vehicle that recovered the flight recorder for Korean Air Lines flight 007, which was shot down by the USSR for violating its airspace. Roby is pictured in Fig. 1.1 (p. 4). For scale, Roby is about one meter in height. Roby is capable of retrieving and carrying about 300 kg, has color TV capability, depth sonar, and various end-effectors for its mechanical arm.

Figure 1.4 (p. 6) is of a small ROV, *Anties*, with its suitcase controller. The ROV's dimensions are approximately 50 cm x 50 cm x 20 cm. A poster behind the ROV indicated that it could be operated from a ship or pier to look for shallow water objects in the vicinity. *Anties* can dive to depths of 100 meters and has a retrieval capability of 20 kg.

Table 2.1
Underwater Vehicles Designed in Both Polytechnical State University
and Design Office Dalnee from 1976 to 1995

Name	Yr.	Depth	Weight in Air	Power Supply	Navigation & Instrumentation	Mission
ROV DVPL-1	1976	100 m	150 kg	220 V, 50 Hz, 1,500 W	Depth gauge, compass, depth sonar transducer, telecamera.	Test of the propulsion management system.
ROV Lortodromia-1P (2 units)	1980	6,000 m	1,500 kg	220 V, 50 Hz, 10,000 W	Depth gauge, compass, depth sonar transducer, short-base hydroacoustic navigation system telecamera, mechanical grab. Course and bearing indicator. (Peleng)	Survey, Coring.
Tethered vehicle Lortodromia - 1B (2 units)	1980	6,000 m	1,200 kg	220 V, 50 Hz, 2,000 W	Depth gauge, compass, depth sonar transducer, long-base hydroacoustical navigation system. TV camera, side sonars, magnetometer, stereo-photo system. Hydrological & acoustical sensors.	Acoustical & magnetics survey. stereo-photo survey.
Tethered vehicle Bober-1	1983	500 m	50 kg	220 V, 50 Hz, 100 W	Depth gauge, depth & side sonars.	Hydroacoustical survey.
Tethered vehicle Bober-2 (2 units)	1984	2,000 m	60 kg	220 V, 50 Hz, 500 W	Depth gauge, depth & side sonars, Photo & TV camera.	Hydroacoustical survey Photography.
ROV Linotip-3" (2 units)	1989	6,000 m	1,400 kg	220 V, 50 Hz, 8,000 W	Depth gauge, compass, log, depth sensor, short-base hydroacoustical system, stereo-photocamera, side & bow sonar transducers, electro-hydraulic mechanical arm, grab.	Hydroacoustical survey, coring, tele-photo survey, rescue operations.
ROV "Linotip-2 (2 units)	1989	6,000 m	1,200 kg	220 V, 50 Hz, 2,000 W	Depth gauge, compass, depth sonar transducer, short-base hydroacoustical system, side & bow sonars, stereo-photo camera.	Hydroacoustical survey, tele-photo survey.
Tethered vehicle Linotip-1 (2 units)	1989	6,000 m	40 kg	220 V, 50 Hz, 2,000 W	Depth gauge, compass, depth sonar transducer, hydroacoustical navigation system with ultra-short base system. Tele-photo cameras, side-sonar transducers, hydroacoustical profile device.	Hydroacoustical survey of natural resources.
ROV Geolog	1992	6,000 m	2,000 kg	220 V, 50 Hz, 2,000 W	Depth gauge, compass, depth sonar transducer, hydroacoustical navigation system with ultra-short base system. Tele-photo cameras, side-sonar transducers, hydroacoustical profile device.	Hydroacoustical survey of natural resources
ROV Roby	1993	500 m	300 kg	3 x 380 V, 50 Hz, 6,000 W	Color TV camera, mechanical arm core-sample device, depth gauge, depth sonar transducer.	Rescue operations, tele-photo survey, coring.

Under Professor Y. N. Kulchin, students have been performing theoretical work on fiber-optic lines, which are sensitive to local pressure change, in order to measure low-frequency acoustic fields in an ocean setting. The objective of the research is to obtain tomographic data from a fiber optic network. Oleg Kirichenko, a graduate student, presented his award-winning poster from the MTS/IEEE "Oceans '95" Conference that discussed a precision method of stabilizing a fiber-optic sensing network to make it suitable for use in measuring low-frequency acoustic signals. A second poster by student O. T. Kamentev reported a self-training two-layer neural network model that allowed increased speed in tomography data processing and reconstruction of the physical field parameters.

CONCLUSION

Far Eastern State Technical University is historically important and forward looking with respect to teaching technology. The institution and its faculty are interested in cooperative alliances for research and ROV design, and student exchanges with the United States and with Pacific Rim countries. FESTU has experience and research strength for the development of special purpose ROVs down to 6,000 meters and has faculty strength in developing theories for sensing and interpretation of deep ocean characteristics.

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Hosts:

Anatoly A. Suponya, Deputy Director
Victor G. Lifshits, Professor; Director of the Center
Oleg V. Abramov, Professor; Head of the Department

BACKGROUND

The institute was established in 1971 by Academician A. A. Voronov, a Lenin-prize winner and well-known expert in cybernetics. The institute was chartered to do research in control theory, computer science, mathematical modeling, and simulation. The institute is presently made up of 250 people including a research staff of 112. Thirteen of this number are doctors of science, and 54 are candidates of science (students). Three academicians are listed along with four corresponding members of the Russian Academy of Sciences. Previous levels in 1991 included a science staff of 175 with 10 doctors and 65 candidates.

The present director, Academician V. P. Myasnikov was absent during our visit, and we were hosted by Deputy Director A. Suponya who made the following points during his initial remarks.

The institute has six departments:

1. Expert Systems Design
2. Research of Control Processes and Reliability Problems
3. Mathematical Simulation of Complex Systems
4. Surface Physics and Design of Semiconductor Systems
5. Development of Non-Traditional New Technologies
6. Information Support for Ocean and Environment Exploration.

Due to the absence of some of the department heads, we had access only to the work performed by departments 2, 4, and 6. We also were given a paper describing the work of department 1. These four areas are discussed in the Research and Development section of this site report.

The institute, in addition to conducting fundamental research in the aforementioned departments, services four educational departments in Far East universities. They have cooperative efforts with at least two other institutes, the Institute of Applied Mathematics and the Institute of Computational Mathematics (Khabarovsk). Funding has decreased since Perestroika, and both scientists and facilities are "lightly loaded" at present. Suponya was not very positive about the future of the institute at these present funding levels.

Funding levels for the institute include about \$450K from the government for fundamental research, \$250K from the government in grants, \$50K from the Russian Academy of Sciences for applied science, and \$100K for new facilities. They used to have cooperative programs with other institutes, but this has evaporated.

Because of the lack of funds, many of their younger scientists have left the institute to take positions in private industry and banking institutions. In fact, the panel observed essentially no young personnel at any of the laboratories visited. They used to have a number of funded joint cooperative programs with other institutes in the Soviet Union that produced funds of about \$350K but presently have very few. Numerous brochures were provided the panel summarizing the work of the institute; however, they were primarily public relations materials and seemed to describe work activities in the past. Discussion of current activities evidenced few recent advances.

RESEARCH AND DEVELOPMENT ACTIVITIES

Due to the short time for this visit, the panel divided into three groups to cover the topics available. Of the various laboratories at this institute, we directly observed only the laboratory associated with information support for ocean research.

Expert Systems Design

The director of this laboratory, Dr. A. S. Kleshchev, was away on a long-term assignment supporting an expert system joint development project in Japan. Past work has been in four areas, including knowledge representation, medicine expert systems, expert system support tools, and hybrid expert systems. From brochure descriptions, much of their work seems to have been in the areas of medical diagnosis and of the recognition of moving objects.

A 1994 working paper (preprint) titled "Expert Systems Based on Metaknowledge" was given to us. The paper describes a metashell concept and asserts that normal methods of

using expert system shells are an evolutionary development process that is adequate for rapid prototyping of relatively uncomplicated systems. However, the use of the metashell includes both evolutionary and revolutionary development tools to deal with rapid prototyping of large and complicated expert systems.

The metashell is a computer-based tool involving software that incorporates organized assistance for modifying the knowledge base, the domain model, and a problem-solving method. The metashell may be viewed as an expert system to help in the construction of an expert system developed from a variety of expert system shells that are presently available.

It was not possible to verify the capabilities and maturity of this approach since we were not able to enter into a dialog with the expert, but it sounds similar to existing expert system concepts available from several sources in the United States. In addition to expert system shells, many tools are available to knowledge engineers, including software tools for knowledge acquisition and knowledge validation, verification and construction of interface. These tools have been in use by knowledge engineers over the past 20 years (Turban, 1995).

Research of Control Processes and Reliability Problems

Dr. O. V. Abramov, the head of the department, described their work in the development of control systems for process control. Much of their work has been to develop system models and computer-based tools for the experimental and predictive evaluation of system parameters and the generation of optimum control strategies.

Dr. Abramov described the range of his department's work and asserted that their approach is different from traditional work in that both the design of systems is optimized as a function of reliability and operational maintenance is optimized on the basis of equipment status. Two computer-based tools developed at the institute and used in the countries of the former Soviet Union were described in handouts.

- "CARD" is a Computer-aided, Reliability-oriented Design System for the design of electronic analog circuits. CARD operates on a low-end PC and offers features for simulation, analysis, and component selection to optimize performance and manufacturing yield on the basis of reliability. Reduced design time, higher manufacturing yield, and reduced cost of breadboarding are cited as advantages of CARD. The tool is also compatible with SPICE, a commonly used design tool in the West. Due to lack of time we did not see a demonstration of the program, nor is it clear an English version is available.
- "FORECAST" is a computer-based technique to determine optimal maintenance strategies for individual equipment. Different techniques are provided depending on

available data and the equipment usage. One technique called Secure Individual Forecasting (SIF) operates with limited (less than 10) status measurements and known performance limits to reduce maintenance costs for high-duty systems where failure is costly or results in "grave consequences." Another technique called Robust Forecasting is available that offers less conservative results than CIF and conventional techniques are also included where large quantities of measurement data are available.

In the past, their capabilities were largely developed for the Soviet military, in particular for Navy ship systems and other applications. Today the group seems to have little if any funding and desires to find users for their expertise and the computer-based tools in the West.

Mathematical Simulation

Responsible personnel were not available. From brochures the scope of their work includes ecological system simulation, geoinformatics, mechanics of deformable solids, numerical analysis, and operator equations.

Surface Physics and Design of Semiconductor Systems

We were introduced to the following researchers and their disciplines by Prof. Victor G. Lifshits, a Soros scientist and director of the laboratory.

Dr. Yuri Gavriluk produces mono-layer silicon on epitaxial silicon substrates, yielding 2-D diodes, for example. The work is done at very low vacuum (10^{-10} torrs) at room temperature in a layering and annealing process. He works in both surface and buried phases. He is working on single mono-layer surface phase deposits on silicon mono-crystals at very low vacuum.

Dr. A. A. Saranin works on co-deposition of elemental hydrogen and various metals to form nm-scale features. In essence, his process produces 2-D precisely-controlled metal agglomerates.

Dr. A. Shaparenko works with special methods of cleaning multi-layer silicon structures.

Other researchers are involved in deposition of silicon-nitride on silicon, both film and buried, and on chromium-silicide depositions on silicon substrate to form epitaxial layers of the silicide. They produce, for sale, an automatic computer-controlled spectrometer (referred to by our hosts as an "Oge spectrometer"). The lab worked with depositing carbon on silicon substrates about 15 years ago. They apparently gave up because, though they were able to form diamond, they couldn't control the process well enough to assure they didn't get other forms of carbon as well. They also work with Dr. Rapinsky at the Institute of Semiconductors in Novosibirsk on Blodgett-Miller films on Si substrate.

In general, the laboratories appeared in good order and adequately equipped to do the types of work described, and the researchers were particularly enthusiastic. Some of the published documents of the institute are listed at the end of this site report.

Development of Non-Traditional New Technologies

Responsible personnel were not available. From brochures, we gathered that the scope of their work includes transport vehicles, electrophysics and electric power engineering, and applied opto-electronics.

Information Support for Ocean and Environment Research

Kandidat Herbeck demonstrated how satellite data is received and processed in his laboratory. He uses data from the U.S. NOAA 10 satellite which provides high resolution sea surface temperature (SST) information. The SST data is taken in five bands: four infrared and one visible. They do not use the Russian *Cosmos* satellite(s) that also have an SST capability due to the fact that these "Sputniks" have a wobble which reduces accuracy of the data.

From analysis of sea surface temperature patterns and temperature anomalies, Herbeck is able to plot sea surface currents. Where there are strong anomaly areas, there are usually ocean fronts. It is in these boundary areas where fishing opportunities are the best. The laboratory produces a predictive information product for fishermen.

Herbeck's laboratory does not work with satellite altimetry data (i.e., the TOPEX satellite) or NOAA's coastal zone color scanner on LANDSAT. They use only SST data.

Their primary geographic area of interest is the coastal waters of the Russian Far East.

SUMMARY

The institute has supported Soviet science in the area of controls for over 30 years. While we were not shown much in the way of active laboratories and saw limited activity, the credentials over the years of this institute are significant. They have been responsible for a number of products used in reliability-centered design of analog electronic systems and in prediction of system reliability. They are also presently active in developing advanced expert systems for a variety of applications. They have also been instrumental in founding an R&D center for microelectronics and a joint stock company named "CENTER." While the SST data imagery was relatively straightforward, the data has proven very useful to fishermen. The institute has also founded Far Eastern University branches for controls and for foreign languages. The Institute for Technical Marine Problems was started at IAPU in the 1970s and spun off as a separate institute in 1982 (see ITMP site report). Most of the

activity observed at IAPU is applied science; however, the institute is quite large and much was not seen due to limited time and the lateness of the hour.

The present viability of the institute is uncertain. Funding is down by more than 40%, and younger scientific personnel have left for better paying careers. There is an air of desperation and a lack of focus about how to move into the new era of funding. Little of what we saw is cutting-edge technology and appears to have stagnated at an early 1990s level. The satellite data analysis and display technology and the reliability centered design tools will only become more outdated unless outside funding for joint programs can be found.

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BACKGROUND

The institute was founded in 1957 as a "physical-technical" research organization. A short brochure describing it lists 25 scientific laboratories, which may be grouped into three broad categories.

1. Laser and nonlinear physics

- Nonlinear spectroscopy of atoms and molecules
- Light-induced drift of atoms and molecules
- Physics of lasers
- Hydrodynamical, acoustical, and plasma turbulence
- Nonlinear phenomena in fibers

2. New information technologies

- Photo-induced phenomena on micro- and nanoscales; optical information storage
- Optical computing systems
- Control of spectral, spatial, and polarization characteristics of laser radiation

- Various laser technologies, including high precision gravimetry
- Precise systems for control and position measurement

3. Task-oriented computer systems

- Microcomputer systems for computer-aided scientific research
- Real-time 3-D computer graphics
- Computer-aided image processing
- Computer networks for data communication
- Computer-aided design in microelectronics

The institute publishes a scientific journal: *Optoelectronics Instrumentation and Data Processing*.

The institute currently has 500 employees, which include three academicians, 25 doctors of science, and 100 candidates for doctor of science, as well as staff and technical support personnel. A major reduction in monetary support from the Russian Academy of Sciences has caused the institute to actively seek sources from domestic industry and various institutes abroad. About half the institute's operating funds are obtained from contracted work. The countries of India, Germany, and Italy were mentioned as sources of contract work for development of specific pieces of hardware.

RESEARCH AND TECHNOLOGY

The WTEC group was first given an overview of current projects which illustrated the research emphasis of the institute. The group was given a tour of several laboratories with demonstrations of some of the experimental equipment.

In optoelectronics the research emphasizes materials and devices development for short wavelength systems. Work is also being done on pattern recognition by means of optoelectronics. The institute has been working about 20 years in computer graphics, having developed a flight simulator for cosmonauts that is still in use, and now are in what they see as the third generation of simulation, which is virtual reality.

Work is being done to develop ferroelectric materials for computer memory storage. Optoelectronics systems coupled with artificial neural networks have been applied to pattern recognition. The latter systems have been successful at automating control of industrial heaters through observation of the flames of the furnace. Finally, mathematical modeling has been well developed for x-ray tomography, and image processing.

The WTEC panel were shown models of gravity measuring devices that have been accepted for accuracy by the International Bureau of Measurement. The gravimeter achieved an accuracy of 10^{-9} gravities, incorporating laser interferometry measurement with a rubidium time standard of 10^{-11} seconds. The gravimeter, with the sensitivity to measure a change in gravity that is due to a change in height by only 1 centimeter, is portable, and can be set up in less than 24 hours time.

The institute's strength in mathematical models and algorithms was demonstrated in two areas. An x-ray tomography system was able to provide a rotatable 3-D-like view of human dental structure that would have applications in face surgery. This tomography system was in trials at a medical institute in Novosibirsk. The system was said to require only about one-tenth of the radiation exposure of a set of x-ray films needed to achieve a similar amount of information. Phillips and Siemens were prospective partners in this project.

Software for high speed detection of objects from satellite images was demonstrated. A space shuttle was detected immediately upon launch by separating it from clutter and noise in a sequence of visual frames from an orbiting satellite. Research is continuing, with anticipated applications for digital processing in acoustics and other areas. Some of the other areas might be classification of the age of arctic ice from radar images, reconstruction of low-contrast electron microscope images of virus particles, and analysis of blood to determine its age dynamics.

Several laser and optical labs were demonstrated to the WTEC group. A precision laser (see laser bench in Figure 2.12) enables computer-generated glass masters for embossed holograms and for the production of precision filters and diffraction gratings. The holograms have application in shaping the laser beam to refine a circular point or to create an approximately square output intensity profile. The same system may provide automatic fabrication of chromium masks for microelectronics. Products from this laser facility were reported to have been certified for accuracy and were then used themselves in procedures to certify the new corrective mirror for the Hubbell space telescope.

The observation of light-induced drift of gaseous materials was reported to have been discovered at the institute in 1979. This "light induced drift" (LID) phenomenon has been investigated over the past 15 years as a means to enrich or separate particles of extremely low concentration. Absorption of laser energy of specific wavelength, which is related to the size of the particle, imparts anisotropic movement to particles in a gas. Excitation may impart velocities up to one-tenth the speed of light. The phenomenon may be used to separate gases of atoms, molecules, as well as certain nuclear spin isotopes. Twelve of the institute's staff are researching this area and are connected to four other institutes — Dubna near Moscow and in the Czech Republic, Italy, and the Netherlands.

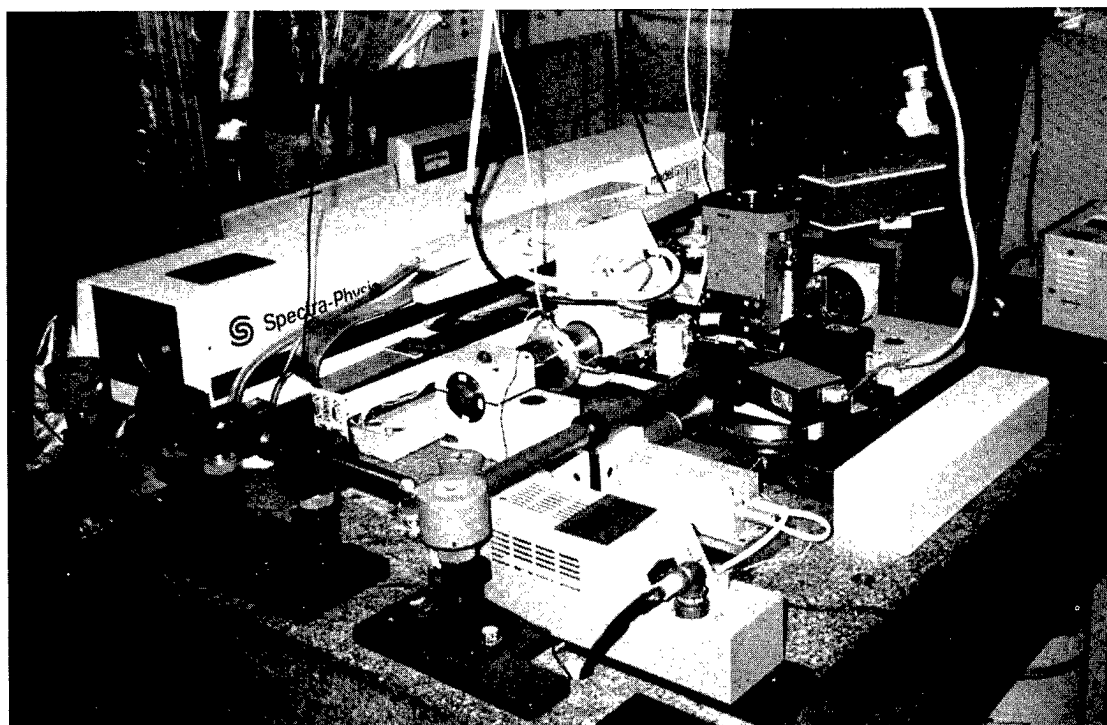


Fig. 2.12. Precision laser.

Additional theoretical and research efforts are producing results in understanding solid state lasers. A goal of one laboratory is to produce solid state laser stability by introducing negative optical feedback. In conjunction with the Institute of Nonorganic Chemistry, experiments have succeeded in demonstrating stable operation of a powerful pulsed solid-state PGT KGd $(\text{WO}_4)_2\text{Nd}^{3+}$ laser (Gulev et al.). Using this method, stability has been achieved for short periods (500 femtoseconds). Other areas of investigation are pulse propagation through non-linear media (fiber), laser material heating problems, and new active media for solid state lasers. In cooperation with the Institute of Nuclear Physics, work is in progress on violet and ultra violet region lasers. A 437 nm violet line was discussed, as was achievement of a 100-watt continuous wave in the blue-green region.

SUMMARY

The Institute for Automation and Electrometry is a very strong basic research institution that is mostly active in laser research, laser materials, laser-produced optical products, and laser-induced drift particle separation. The institute's precision gravimeters are of direct interest to the ocean technologies area. In addition, the mathematical algorithms and advance signal processing techniques that have been developed may have relevance in the marine environment for target detection in high noise and for tomographic presentation of various structures. The institute expressed interest in international cooperation for both research and commercial projects.

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BACKGROUND

The Institute of Chemistry was established in 1971 by Academician Yu. V. Gagarinsky from the Chemistry Department which was begun in the 1930s. The current staff is 200 (345 in 1991) with a budget of about \$200K; this, according to Prof. Shchipunov, relates to salaries which are below minimum living levels. The institute is composed of 14 laboratories and an engineering-technical center (each is described in the referenced institute brochure). Although we spent about three hours at the institute, much of that time was spent in the director's office. We did get to tour two laboratory areas, but again because we talked with the researchers in their offices, we did not have the chance to view laboratory equipment.

The High Technologies Association is a public entity, founded mid-1994, that assists young researchers trying to start high technology businesses. There is now not enough funding for the RAS; the federal budget is 10% that in 1985. Many researchers have moved out of RAS institutes into business. The High Technologies Association was established to give these researchers specific help in the areas of business management, advertising, marketing, and legal matters. It also represents the entrepreneur before the authorities. The High Technologies Association is supported by USAID grants. It currently has 12 members; each is charged \$100 annual dues. The association works to

assure that it is not marketing competing technologies, which helps to explain the modest size of its membership. The president, Academician Vyacheslav M. Bouznik, was for five years the director of the Institute of Chemistry.

RESEARCH & DEVELOPMENT

The Laboratory of Inorganic Fluorides

Under laboratory head Prof. V. M. Bouznik, the Laboratory of Inorganic Fluorides does research and analysis in the following areas:

- Fluoroplastics (Teflon) for use in the nuclear power industry. This material is also used for fillers in medical ointments and cosmetics and as coatings for artificial (metal) bones.
- Low-cost fluoroplastic production. The laboratory produces and markets ForumO, a motor oil wear-reduction additive being touted as a Slick-50 competitor. It has a smaller and more uniform particle size than Slick-50; see product comparison in Figure 2.13 and ForumO particle size analysis in Figure 2.14 (both in Russian, but easily understood). The researchers claim that the smaller particles adhere to the metal parts better — in addition, they use what they call modified fluoropolymers with active centers, also for better adhesion. The active center is probably a side group of the polymer which reacts with surface oxides of the metal to chemically bond the fluoropolymer to the metal. Their product is effective up to 300°C; wear is reduced 2-10 times; oil life is increased 2 times; friction is reduced 20%; and fuel efficiency is improved 10%.
- Cathode materials using a fluoropolymer coating on lithium battery cathodes. Their materials are patented and can double the capacity of lithium batteries. A specific performance comparison is shown in Table 2.2. They have discussed this technology with Eagle-Picher.
- Prof. Bouznik sees two main problems associated with the use of fluoroplastics: (1) they are difficult to plate on metal (though, from what is reported above, they have had some success in overcoming this problem) and (2) they are a potential environmental problem since they cannot be destroyed completely — there will be 40% waste material.
- Their major contribution is their fluoroplastic powder synthesis process. Teflon powder normally costs \$500-1200/kg if one wishes to produce it an environmentally sound way; their process is environmentally sound, costs much less, and produces 0.35 mm average particle size compared to the 2-5 mm material normally produced in the United States.

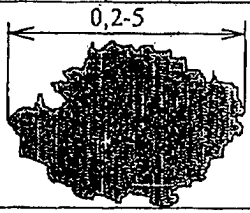
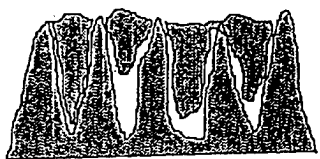
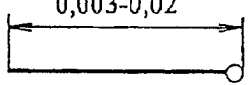

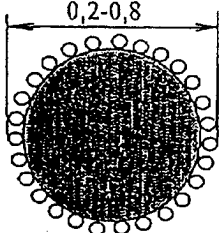
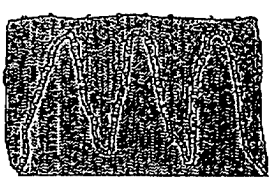
Товарное название, химическое название, формула	Размер и форма частиц, (молекул), мкм	Взаимодействие с поверхностью, ▽9	Цена 1 флякона для легкового автомобиля, \$, (страна)
Slick-50, политетрафторэтилен, (C ₂ F ₄) _n , n=1·10 ³⁻⁴			25 (США), 45 (Россия) 125 (Япония)
АСПЕКТ- модификатор, перфторполи- пропиленоксид, ПАВ, CF ₃ CF ₂ O[CF(CF ₃)CF ₂ O] _n CF(CF ₃)COF, n=10-50			4-5 (Россия)
ФОРУМ, поверхностно- активированный кислородом политетрафторэтилен (C ₂ F ₄) _n COF, n=1·10 ²⁻³			9-10 (Россия)

Fig. 2.13. Product comparison.

Table 2.2
Performance Comparison*

"New Cathodic Materials for Lithium CCS were produced on the basis of graphite with power-consumption up to 3.5 kW hr/kg for tension of broken chain (TBC) 3.8-5.2V (reserves) and with power-consumption up to 2.2 kW hr/kg for TBC 2.0V (long-term employment) and on the basis of Teflon and hydrolytic lignine with power-consumption up to 3.5-4.8 kW hr/kg for TCB 3.2 V."

Energy	Substance	Reaction	E ₀ , V	A·hr/kg	W·hr/kg
☺	Ag ₂ O	+ Zn → ZnO + 2Ag	1.6	179	287
☺	CF	+ Li → LiF + C	3.2	706	2260
☺	CF ₂	+ 2Li → 2LiF + C	3.2	1100	3520
☺☺	2C ₄ O ₃ F _{1.5}	+ 15Li → 3LiF + 6Li ₂ O + 8C	3.2	1142	3654
☺☺☺	C ₉ O ₆ F ₆	+ 18Li → 6LiF + 6Li ₂ O + 9C	3.2	1520	4860

*[Retyped verbatim from the original supplied by Institute of Chemistry. Note that Russian notation for decimal point, i.e., comma, has been replaced by U.S. notation (period).]

Рис.1 Дисперсный состав и микрофотография порошка УПТФЭ.

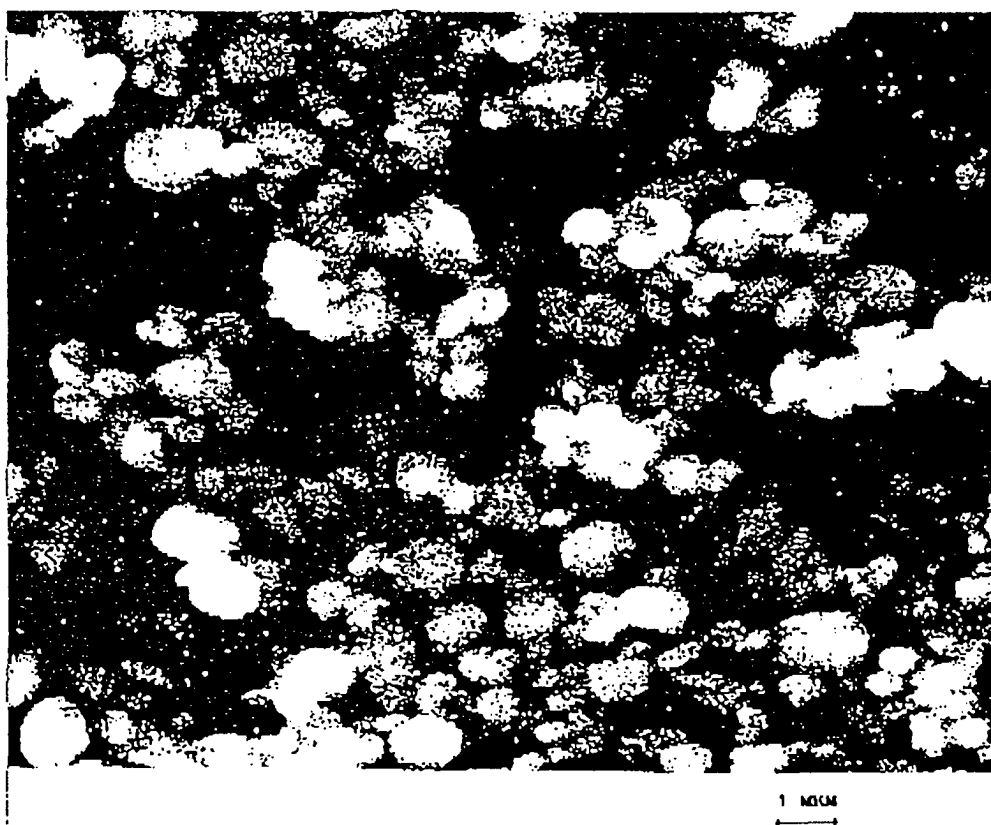
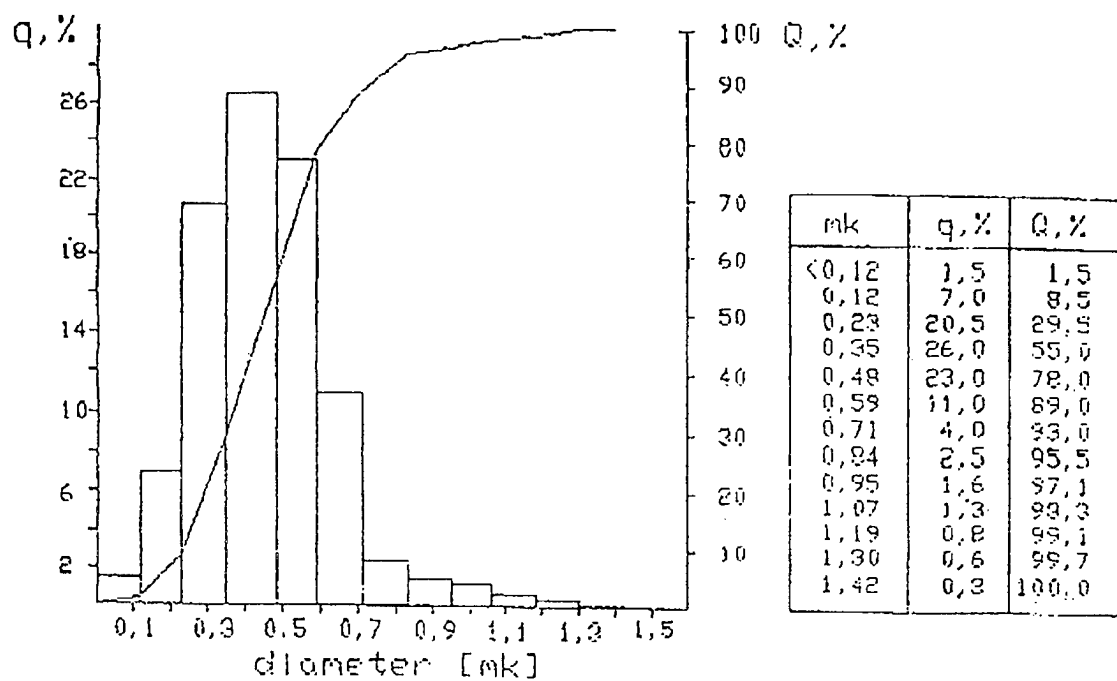


Fig. 2.14. ForumO particle size analysis.

The Laboratory of Sorption Processes

Dr. V. A. Avramenko, head of the laboratory, works on the following technologies:

1. A water supply cleaning filter which uses highly selective ion-exchange for sewage cleaning or even oil refining
2. Adsorption material which is used to clean water of liquid radioactive waste. They claim their radioactive waste separation material will filter out any radioactive isotope.
3. V. A. Avramenko stated that the choice of the correct solvent is important in their separation and filtering processes.

The Laboratory of Protective Films

S. V. Gnedenkov, assistant head of the laboratory, provided an overview of work being performed on the micro-arc oxidation coating of metal surfaces:

1. Their coatings have reduced marine corrosion on titanium and titanium alloys up to 200 times.
2. Their dry coating on titanium has reduced friction 12-18 times.
3. They also work on cookware coatings and coatings for aluminum and titanium pistons that have micro-hardnesses up to 105 MPa.
4. This techniques can be used as a primer before application of a fluoroplastic coating or as a base before lacquer application.
5. They showed us samples of their variously-colored coatings which can be used on exterior metal framing for industrial applications.

Dr. Gnedenkov noted that their process produces no pollution.

The Laboratory of Marine Corrosion

The Laboratory of Marine Corrosion works on the following:

1. They have developed a thermoplastic-based anti-biofouling paint that has environmentally safe biocide components; the paint is effective for four years. They admit, however, that they must do more testing to certify the environmental safety of their paint.
2. The laboratory also runs the Marine Corrosion Station, which is unique in Russia.
3. They are interested in starting an international center for corrosion studies at the station.
4. The main directions of the laboratory are to test any materials a customer might choose at the Marine Corrosion Station.

The Laboratory of Fluoride Glasses

Professor Yura A. Shchipunov gave information about this laboratory headed by Dr. V. K. Goncharuk:

1. Phase behavior, structure, dynamics, and processes of glass formation in mixtures of fluoride, bromide, and chloride salts of transition metals are studied.
2. New glasses are being developed for fiber optics and laser equipment that offer special properties when compared to quartz.

The Laboratory of Light-Transforming Materials

Dr. A. G. Mirochnik, assistant head of the laboratory, presented the main research themes:

1. They introduce complexes of rare-earth metals into polyethylene films to convert UV radiation to IR for application in greenhouses. We also discussed the possibility of using these types of substances to filter various types of radiation.
2. A fluoro-luminescence method for detecting AIDS in blood. Suitable compounds are under investigation. They expect that the method is the best one for detection. This is an antigen detection method instead of the current test which tests for the presence of AIDS antibodies. The antigen method is much simpler and more straightforward, promising faster testing (that can be performed by more facilities). FDA approval for the use of this method in the United States was expected in 1996.

SUMMARY

The institute's brochure listed several analysis techniques which would enable them to do the work described above. These techniques are nuclear magnetic resonance, electron spin resonance, nuclear quadrupole resonance, electron spectroscopy for chemical analysis (x-ray photoelectron spectroscopy), extended x-ray fine analysis, and Mossbauer effect analysis. Unfortunately, time did not allow us to view any of this equipment, nor interesting processes such as their fluoropolymer synthesis.

Subjectively, this institute and its staff left a positive impression — it is likely to be one of the survivors. The staff were enthusiastic and seemed strongly entrepreneurial. They have started working on such new themes as self-organized structures of phospholipids and enzymatic synthesis in disperse media (Prof. Yu. A. Shchipunov, head of the Laboratory of Colloid Systems and Interfacial Processes) and fullerene derivatives (Dr. A. M. Ziatdinov, head of the Laboratory of Electron Physical Methods of Investigation). The building's physical condition appeared good, but unfortunately, it is not possible to comment on the state of their analytical and synthesis facilities.

Site: **Institute of Computational Technologies
Russian Academy of Sciences, Siberian Branch
Ac. Lavrentiev Ave., 6
Novosibirsk, 630090, Russia**

Date Visited: October 30, 1995

WTEC Attendees:

R. Blidberg (report author), S. Chechin, M. J. DeHaemer, J. Moniz

Hosts:

Academician Yuri Shokin, Director. Phone: (3832) 350050 (351242 FAX)

Email: shokin@ict.nsk.su

Prof. Victor M. Kovenya, Deputy Director, Head, Department of Mechanics of Continuous Media. Phone: (3832) 351168 (351242 FAX). Email: kovenya@ict.nsk.su

Prof. Anatolii Fedotov, Deputy Director, Head, Department of Informational Technologies. Email: fedotov@ict.nsk.su

Dr. Sergey Golushko, Scientific Secretary. Phone: (3832) 350785 (351242 FAX). Email: golushko@ict.nsk.su

RESEARCH & DEVELOPMENT

The institute has a staff of 120 people working in 12 laboratories. Their applied [i.e., military] work has now almost stopped. They are now adapting their developed software to other applications.

Department of Natural Phenomena/Processes

The department has four laboratories:

Laboratory for Numerical Analysis — Dr. Gayaz Khakimzyanov, Head

This laboratory deals with the development of the theory of difference schemes, algorithms for numeric solution of the problems of continuum mechanics, and relevant applied software development. The primary focus is on the development of adaptive grids for 3D models of hydrodynamic processes.

Laboratory for Modeling of Wave Processes — Dr. Boris Chubarov, Head

Research in this laboratory mostly concerns the development of algorithms for the numerical modeling of the transformation of long surface gravitational waves on the water

surface. Special attention is paid to nonlinearly dispersive approximations of shallow water theory. Several different models were discussed. The first was a simulation of a tsunami: its travel time and wave amplitude were predicted by introducing data describing a number of parameters associated with the initial event (Chubarov 1992). The resulting surface waves were displayed on a PC.

Laboratory for Modeling of Atmospheric Processes — Prof. Gdalii Rivin, Head

This laboratory deals with the solution of mathematical problems associated with the time and space reconstruction of “meteoelements fields” based on observational data from direct and indirect probing of the atmosphere, i.e., the development of numerical methods for analysis of meteorological data, initialization, atmospheric models and “meteofields” visualization.

Laboratory of Interval Analysis — Dr. Valerii Kobkov, Head

Broad classes of numerical algorithms for optimal solution of “external problems” for the interval linear algebraic system (PSS and PPS algorithms) have been developed. A complete “technological chain” has been developed to solve the linear problems of tolerances — a generalized stabilization problem — for interval linear static problems.

Department of Mechanics of Continuous Media

The department has five laboratories with a total of 30 researchers.

Laboratory of Computational Aerodynamics — Dr. Sergey Cherny, Head

This laboratory mostly works on the development of effective numerical algorithms for the solution of aerodynamics problems and their application to different spheres of science and technology. The focus is on aircraft modeling problems, such as modeling internal flow in turbines. Models simpler than Navier-Stokes are used, since the lab has limited computational capability. A demonstration was run representing the internal flow in a turbine. It represented the calculation of 30,000 points in that flow.

Laboratory of Computational Hydrodynamics — Gennadii G. Chernykh, Head

This laboratory mostly does research on solutions properties of equations with sign-changing viscosity coefficients, construction of projectional grid solution methods for elliptical and parabolic problems with the interval and boundary layers, and numerical modeling of flows of incompressible fluids. Although they originally studied turbulence in ships' wakes, they are now investigating free turbulence using semi-empirical models of turbulence.

Laboratory of Plasma Physics — Galina Dudnikova, Head

This laboratory primarily investigates non-stationary processes and cosmic plasma using several different levels of numerical models (MGD, kinetic, hybrid) and dimensionality (1D, 2D, 3D) developed in the lab. The researchers are using approximation techniques to investigate problems such as the Boltzman model for semiconductors. They are also using this technique to look at hydrodynamics problems. One simulation was shown utilizing a 486-type PC that modeled plasma flow. This was a hybrid model using several approximations and a technique of splitting the problems into simpler pieces, then recombining the results to obtain a 3D model. A simulation was run of a laser pulse hitting a plasma bubble. The kinetic equations of the interaction of one million particles have been represented.

Laboratory of Statistical Models and Methods — Prof. Yurii Grigoriev, Head

This laboratory specializes in research on statistical models of rarefied gas, hydrodynamic turbulence, and coagulation theory. A demonstration was shown in which a gas jet and the control of that jet were simulated over time.

Laboratory of Computational Physics — Prof. Grigorii Gagiyak, Head

This laboratory's work can be divided into five areas:

1. Working out models to describe charge accumulation in an undergate insulator in strong electric fields and under external radiation
2. Numerical simulation of photoresponse of different photodetectors (i.e., differing wavelengths, materials, and temperatures)
3. Numerical simulation of technological processes (e.g., CVD reactors, plasma-chemical reactors for deposition and etching, molecular beam epitaxy, and thermal oxidation of silicon)
4. Simulation of absorption and desorption processes for atoms and molecules applying quantum-chemical methods in cluster approximation
5. Simulation of defects and reaction barriers in solids applying quantum-chemical methods in cluster approximation

Department of Informational Technologies*Laboratory of Information and Telecommunications*

The Laboratory of Information and Telecommunications provides a communication network for research, data banks, and data analysis in support of all the institutes at Akademgorodok. An effort is underway to implement Internet access for these institutes

via the Moscow backbone. This project will include networking all of the institutes to a central location in Akademgorodok, then to Novosibirsk, then to Moscow via satellite link.

- 19.2 kB to Moscow at the time of the WTEC visit; they want 2048 kB to Moscow
- Set up communications in local area, then to Moscow
- Plans are for land line, then F/O in '96, then satellite link in '97
- Local network server is a SPARC 10

Laboratory of Data Analysis

- Dealing with random errors in data and the reconstruction of that data
- Decision support in the event of natural disasters
- Using expert systems
- Production rules
- Mathematical logic (non-classical logic) — similar to fuzzy logic, but different since it is a noncontinuous logic

Laboratory of Systems Support of Fundamental Research

This organization provides software services to the research institutes. The laboratory is setting up a number of services for the research community as summarized below:

1. The aims of the information network are as follows:

- Creation and accumulation of information resources
- Information and computing service and support of foundation investigations
- Organization of computational and information communications
- Support on-line and off-line access to the global Russian and international data bases, library (Email, FTP and http access)
- Support of communications among scientists
- Integration computing (hardware and software) and memory for solving scientific problems
- Creation and support of electronic publications (contents of journals, monographs and proceedings of conferences); an electronic notice board and notices about seminars, conferences, etc.; full text databases; abstracts, full texts of working papers, dissertations, preprints; and electronic journals) in English and Russian
- Stimulating the participants to master new informational technologies

- Creation of databases on the intellectual potential of the Siberian mathematicians (Directory of Siberian Mathematicians) and mathematical organizations (WWW-access, FTP-access)
- Notice board (conferences, seminars and other events) and teleconferencing
- Remote access to supercomputers

2. Information Service (Information Data Bases) — At the base of the ICT SB RAS the information servers (WWW, FTP & Email access) will be created that contain the following information systems:

- Contents of mathematical journals — "Current Contents" (NIS, SB RAS, NA-Net, Informregister etc.) (WWW, FTP and Email access)
- Notice board (conferences, seminars and other events) (WWW, FTP and Email access)
- "Teleconference" of Siberian and Far Eastern mathematicians SM-Net (mathematical digest, electronic communications, publications, etc.) (WWW, FTP and Email access)
- Brief passports of the institutes of mathematical profile with reference to the electronic addresses of the institutes (WWW, FTP and Email access)
- Directory of Siberian and Far Eastern mathematicians (similar EMIR system) with references to electronic addresses of the mathematicians (WWW, FTP and Email access)
- Electronic versions of the "Siberian Mathematical Journal" and the journal "Computational Technologies"
- On the basis of the ICT SB RAS a file server containing licensed software obtained through the project and from other sources will be created
- A library database will be created on the annotations of publications
- Provision of systems of preparation of documents and mathematical texts including TEX-service, exchange and access to own and outside services, use by Russian and international (databases, information systems, systems of computer algebra, applied mathematical packages — software not requiring purchases of licenses)
- Support the control problems of SB RAS
- Creation distribution hypertext data bases (multi-media information, geoinformation)
- Electronic access to the literature
- Current contents (journals, books and other)
- Electronic publication (electronic journals, reports, preprints, books)

- TEX-mirror (FTP and Email access) containing CTAN (Comprehensive TEX Archive Network) archive of editor system TEX for author's and publisher's preparation (formats LATEX, AMS-TEX, AMS-LATEX and plain) of mathematical texts in English and Russian in MS-DOS, OS/2 and UNIX environments
- Training-consulting centers on telecommunications software and TEX-service

REFERENCE

Chubarov, L. B., et al. 1992. "Using numerical modeling to evaluate tsunami hazard near Kuril Island." *Natural Hazards* 5; 293-318. Kluwer Publications, Netherlands.

Site: **Institute of Marine Biology**
Far East Branch, Russian Academy Sciences
17 Palchevsky Street
Vladivostok, 690041, Russia
Phone: (4232) 310905
Fax: (4232) 310900

Dates Visited: October 23, 1995
October 27, 1995

WTEC Attendees:

D. Walsh (report author), H. B. Ali, R. Blidberg, S. Chechin, M. J. DeHaemer, L. Gentry, J. Moniz, J. B. Mooney

Hosts:

Dr. Vitaly G. Tarasov, Acting Director
Leonid V. Dolgov, Ph.D., Assistant Director, Foreign Relations

BACKGROUND

The Institute of Marine Biology of the Far Eastern Branch of the Russian Academy of Sciences was founded in 1967. At the time of the WTEC visit, this organization employed 450 persons (300 research staff and 140-150 engineers and technicians). Within the Institute there are 20 laboratories and an auxiliary services group. In addition, there are four field stations and the Far East State Marine Reserve. Two smaller research vessels support seagoing projects.

In addition to the research ships, the institute conducts many dives to collect specimens and to do *in situ* research tasks. Most of the scientists are divers.

The basic focus for research activities is the near-shore coastal areas of the Russian Far East. The goal of the research is the balanced, conservative use of the marine resources of the region and the protection of these resources from environmental damage.

The WTEC team was at the institute for about two hours on the first visit and one and a half hours on the second. Located in a large building complex next to the ocean, just to the north of downtown Vladivostok, the facilities there appear to be very extensive. However, the entire first visit and most of the second were spent at the conference table in the acting director's office. Some handouts were given to the team and these are cited in the references section of this site report.

As with most of the other organizations visited during this trip, the institute is suffering from severe budget reductions since Perestroika in 1989. In order to maintain as many programs as possible and to keep their staff current, they have been developing cooperative programs with U.S. and Japanese marine science institutions. In the United States the work has been through the University of Washington and the University of Alaska. In Japan the work has been primarily with Hokkaido University.

The acting director said that Peter the Great Bay has the greatest biodiversity in East Asia as this area is influenced by both the Kuroshio (warm) and the Oyashio (cold) currents. Thus it is a very rich area for marine biological research.

RESEARCH AND DEVELOPMENT ACTIVITIES

The research activities of this institute fall into the following basic categories:

- Study of the species composition, distribution, and ecology of the marine flora and fauna and of the biological productivity of shelf zones of the far eastern seas of Russia and the adjacent waters of the Pacific Ocean
- Research and development for the preservation and restoration of marine biota
- Study of the adaptations, ontogenesis, and evolution of marine organisms

In terms of specific activities, work is being done to study the effects of dredging in the Kuriles, the impact of nuclear waste dumping in the Sea of Okhotsk, the assessment of fish stocks in Bering Sea and Sea of Okhotsk, and the biofouling of offshore platforms (Sakhalin). In addition, there is environmental assessment work being done in the river delta area where the governments of North Korea, China, and Manchuria propose building a major new seaport and railhead. The Russians believe that there will be too great an opportunity to have major pollution incidents in an area that is ecologically very fragile.

The team was particularly interested in Dr. Terasov's explanation of his research in the Kuriles at a site where both photosynthesis and chemosynthesis processes are found in virtually adjacent areas. Furthermore, the chemosynthetic activity was at depths as shallow as 20 meters. Normally, such activity is found at benthic depths in the sea. The site in the Kuriles is a volcanic crater which has one side just barely open to the sea. It is an ideal location to study some of the fundamental biological processes in the sea.

Dr. Terasov mentioned that he had a videotape of the work he had done at the site. Time did not permit viewing during the first visit, so the WTEC team return to the institute for this purpose on Friday, October 27.

SUMMARY

The Institute of Marine Biology appears to have an important mission in this region. The work that it does helps optimize the rational use of marine resources while at the same time studying those influences that could lead to degradation of resources through pollution.

REFERENCES

Institute of Marine Biology. 1995 pamphlet describing the institute and the work of its laboratories. Contains a listing of publications published by each laboratory.

Institute of Marine Biology. One-page handout, dated 12/93, which provides a shorter version of the pamphlet's information.

Site: **Institute of Marine Technology Problems**
5a Sukhanov Street
Vladivostok, 690600, Russia
Phone: (4232) 228350
Fax: (4232) 226451

Dates Visited: October 24, 1995
October 25, 1995
October 27, 1995

WTEC Attendees:

R. Blidberg (report author), H. B. Ali, S. Chechin, M. J. DeHaemer, L. Gentry, J. Moniz, J.B. Mooney, D. Walsh

Hosts:

Mikhail D. Ageev, Professor, Director of the Institute. Email: ageev@eastnet.su
Dr. Vladimir V. Nikiforov, Scientific Secretary
Dr. Solotarov, Acoustic design/systems
A. Shcherbatjuk, Navigation
Alexander V. Inzartsev, Control System
Boris Kasatkin, Hydroacoustic systems for tracking and navigation

BACKGROUND

The Institute of Marine Technology Problems was founded in 1988. It is directed by Mikhail D. Ageev, a full member of the Russian Academy of Sciences, and fellow of the Marine Technology Society. The scientific staff of the institute numbers about 90; one of them is an academician of the RAS; another is a correspondent member of the RAS; three are academicians of the Academy of Engineering Sciences; and nineteen are professors and doctors of science.

Facilities include about 2000 square meters of laboratory room, CAD engineering, experimental production workshops, a high-pressure chamber for deep water equipment tests, and a small research vessel. Scientific investigations and technical developments are carried out in four fields: underwater robotics, hydrophysics, renewable energy resources, and marine ecological systems monitoring.

The primary focus of the institute is the development of new methods and principles to utilize autonomous undersea systems for research and exploitation of the ocean. Scientists and engineers in the underwater robotics department develop principles of autonomous underwater vehicle movement control, develop algorithms that allow these systems to

interact with their surroundings, and continually improve the on-board systems. Experimental prototypes of autonomous underwater vehicles (AUVs), tethered and towed vehicles (ROVs), and navigation and positioning systems are designed at the institute. Experimental operations of modular AUV systems such as the MT-88 series (Fig. 1.6, p. 8) have proven the utility of these vehicles in carrying out scientific research, area search, and geological surveys, especially in deep water. The institute takes part in international projects in this field and has close scientific and technical contacts with universities, institutes and companies in China, France, South Korea, and the United States.

A second focus of the institute is carried out by the Department of Hydrophysics headed by Victor A. Akulichev, the correspondent member of the RAS, professor, fellow of the Acoustical Society of America, and member of editorial board of such journals as *Ultrasonics* and *Russian Physical Acoustics*. This department investigates large-scale inhomogeneities of the water medium (frontal zones, synoptic eddies, currents, etc.) and small-scale inhomogeneities of the water medium (suspensions, gas bubbles, sound scattering layers, turbulence, plankton, etc.) using acoustic methods. Acoustic sources with frequencies of 100 to 1000 Hz are towed at depths of up to 100 m. In addition, deep water sound sources operating up to 1000-1500 m can be used. Drifting, vertical receiving systems with hydrophones at any depth from 0 to 1000 m are used as the receiving array. Using these highly directional parametric acoustic sources and special processing methods, researchers in the department investigate remote acoustic spectroscopy. The experiments have shown the possibility of recording the spatial variability of plankton and suspensions in the upper ocean layer in vertical and horizontal directions. Other results show the possibility of measuring gas bubble concentrations, and the spectral composition and variability of collapsing surface waves or other similar disturbances.

The Laboratory of Renewable Energy Resources and Non-traditional Energetics is headed by A. K. Ilyin, professor, member of International Academy of Sciences, and member of Engineering Sciences Academy and Transport Academy of Russia. This laboratory conducts resource estimation of renewable power sources as well as investigates new technologies to take advantage of alternative energy systems. New concepts have been developed and experiments performed to investigate the use of the thermal energy of the ocean, solar energy, energy of ocean tides, sea waves, wind, and biomass. Some industrial solar water heater units were constructed using laboratory designs.

The Division of Ecologic Systems Monitoring develops automated systems for ecological research, for monitoring the water medium and aquaculture using AUVs designed at the institute. The problems of automating industrial wastewater hydrochemical analysis are defined. The laboratory participates in developing automated systems for ecological monitoring of the Russian Far East. The division is headed by V. I. Dulepov, professor, full member of the Academy of Engineering Sciences and of the International Academy of Sciences of Ecology.

The institute takes part in international projects in the field of ocean science and carries out expeditions on the scientific vessels of FEB RAS.

The WTEC panel toured both the institute located in the center of Vladivostok and a test facility located some distance from the institute. While at the institute, we were shown various hardware and listened to a number of presentations focused on various aspects of AUV system and subsystem technology. The following two summaries detail the information we received; the first focuses on AUV systems and technology whereas the second describes the test facility we visited. It must be stated that the panel was very pleased with efforts of the staff of the institute to provide us with information and to create an environment that encouraged sharing information.

IMTP AUV DESIGN AND EXPERIENCE

The staff of the Institute of Marine Technology Problems has been developing AUV technology since 1972. Several AUVs have been designed, developed, and tested during sea operations.

SKAT Vehicles

SKAT (Fig. 1.5, p. 8) and *SKAT-GEO* were designed and built in 1973-76 for operations on the shelf. The original *SKAT* comprised two large hulls, forming a catamaran-like configuration. Gradually other devices were added. These devices were packaged in small containers and added to the original configuration. Operational experience with the *SKAT-GEO* showed that it was necessary to have a rather large number of these containers. This led to the idea of modular construction. The propulsion system containing four stern propulsors was another success of these early development efforts. *SKAT-GEO* was designed for 300 m depth, is 2.3 m in length, and has a mass of 450 kg. The vehicle was equipped with photo and TV cameras with a video recorder and CTD sensors.

Use of the *SKAT-GEO* in 1974 in Lake Baikal was the institute team's first experience using AUVs to undertake practical tasks focused on solving environmental conditions. The expedition was organized to check the lake pollution by industrial waste waters of the Baikal cellulose-paper plant. The AUV was equipped with hydrochemical sensors and a multichannel data storage system. The AUV made a number of transits at various depths in the area adjoining the plant's waste waters discharge. The measurements allowed a map to be made describing the spatial variability of the impurities polluting the water.

A route survey using video sensors was undertaken in the White Sea. The goal was to identify objects that had been detected with the support ship's side-scan sonar. Following these operations, the *SKAT-GEO* vehicle was used for several seasons in the Sea of Japan to monitor marine plant life underwater.

6000-Meter AUVs (*L1* and *L2*)

In 1976 work was begun to develop an AUV capable of operation to 6000 m. Two prototypes were developed, *L1* and *L2*. Initial testing of these systems was undertaken in 1979 with a full 6000 m test completed in December 1980. At this time a vehicle reached a depth of 5,930 m. These vehicles were used in operations in the Atlantic Ocean, the Pacific Ocean, and the Sea of Japan beginning in 1982.

AUV *MT-88* and Prototypes

The AUV *MT-88* (Fig. 1.6, p. 8) has a traditional body configuration. It is composed of buoyancy blocks and fairings. The basic equipment is housed in 14 relatively small containers. The body is subdivided into several sections. This method of construction allows for easy modification since sections can be added or removed due to the modular type of construction.

Main characteristics:

Rated water depth.....	6000 m
Maximal speed	1m/sec
Underwater endurance	6 hours
Mass	1 ton
Overall dimensions	3.8 x 1.15 x 1.1 m; .7 m in diam.
Power source	silver-zinc battery, 16 cells, 100 A hours

A control station is placed on board the support ship containing a central computer, transceiver units of the acoustic positioning system (APS) and a communication link, recorder and other devices. This control station provides pre-launch AUV control and program input and displays AUV and ship movement in real time. An acoustic link allows modification of the vehicle's program. The computer also allows downloading and preliminary processing of data from the on-board vehicle storage devices after the AUV's recovery.

On-board vehicle subsystems share a common communication channel. This permits control instructions to be passed over a common electrical connection. These electrical connections can then be kept similar even when the vehicle is reconfigured to accomplish a different task. Program downloading prior to the vehicle's launch, data retrieval after its recovery, and vehicle operation in towed mode (pre-dive testing) are conducted over this communication channel .

The vehicle's descent and ascent are carried out by utilizing cast-iron ballasts. The AUV descends with two ballasts, one of them being thrown off when set water depth is reached, the other when the operation is over.

The propulsion system used in the vehicle consists of four main propulsors installed in the stern at an angle of about 20° relative to the vehicle longitudinal axis. By controlling motor rotation velocities a thrust vector can be generated in any desired direction, thus providing good vehicle maneuverability. Simplicity and homogeneity are also the system advantages. Instead of one velocity and two positional servo-systems (one propulsor with controlled velocity, two rudder turn gears), four identical velocity servo-systems are utilized. It is possible to use only three propulsors but some capability is sacrificed. Reverse is also provided for emergency cases. This capability was once successfully tested in a situation where the vehicle got hung up on a thin metallic object that was not detected by the onboard obstacle avoidance sonar.

Modular AUV construction has been used in IMTP designs since 1978. This technique allows for easy modification and reconfiguration to meet the needs of various mission tasks. Moreover, underwater devices of different kinds can be assembled easily. For example, a towed vehicle was designed, built, and used during at-sea operations. Thanks to the availability of standard elements these vehicles were built in a few months. Using this modular approach the institute has designed a number of standard components, chassis, functional units, electronic systems, sensors, hermetic connectors, and other devices which most AUVs must contain.

In 1989 initial tests were conducted to map manganese nodule deposits using the *MT-88* in the Pacific Ocean. The operation was carried out on the *Geolog Pjotr Antropov* in cooperation with the international organization "Interoceanmetall." The goal of the operations was the determination of density and uniformity of nodule deposits in a defined area of the ocean. First, hydroacoustic profiling was performed by means of the AUV's side-scan sonar. Following this survey, the AUV conducted a photo survey over an area of 100 square kilometers. The survey tracks were determined during the first AUV dive such that the survey paths would take into account the direction of bottom currents. This survey was further complicated by the fact that the survey routes forced the AUV to transit "shadow zones" where the APS became ineffective.

The *MT-88* prototype was used for search and inspection of two Soviet nuclear submarines that had sunk. The first submarine sank in the Sargasso Sea in 1986 at depth 5500 m and the second one *Komsomolets* in the Norway Sea in 1989.

The operation in the Sargasso Sea (January through April 1, 1987) was conducted using only the AUV. Although the weather conditions were severe, the AUV was launched up to sea state 4. The first 20 AUV dives utilized the onboard side-scan sonar to search for the sunken submarine. After its detection, 22 dives were undertaken to inspect the submarine. Over 40 thousand still pictures of the bottom were taken, 25 thousand of which were taken in the area of the sunken submarine.

To find the sunken submarine *Komsomolets*, a towed vehicle equipped with side-scan sonar and radiometer was used. This option was considered the better option since the

water depth was 1650 m. On May 16, the submarine was detected and its location determined. Exact coordinates of the *Komsomolets* were transmitted to the scientific-research ship *Mstislav Keldish*; the manned vehicles *Mir-1* and *Mir-2* were then deployed.

As part of this effort, the AUV was used to gather photographic data of the sunken submarine. Survey conditions and appropriate survey paths were determined during the first five AUV dives. After this, 12 dives were conducted that allowed the AUV to gather about 150 still pictures that were then used to develop a mosaic of the area.

AUV *Typhlonus*

The accuracy of physical field measurements at abyssal depths during some oceanological missions (for example, fluctuations of current velocities) depends to a great extent on movements of the platform on which sensors are installed. To obtain satisfactory accuracy, platform velocity must be highly stable (vehicle velocity stabilization with an error not greater than fractions of 1 cm/sec). Other applications such as synthesis of acoustic array apertures or gravity measurements can be carried out only with minimal deviations in platform displacement or acceleration. The AUV *Typhlonus*, characterized by a long range and an improved stabilization system, has been developed to satisfy these requirements. The hull has a streamlined shape, though it is made up of modules similar to those used in the *MT-88*.

Principal performance characteristics of *Typhlonus*:

Rated depth	2000 m
Maximum velocity	2m/sec
Mass	900 kg
Overall dimensions	0.8 m dia x 3.5 m
Capacity of battery	(27 V) 300 (600) Ah

Duration and range depend on the battery capacity and power of the user equipment. For 300 Ah battery and 30-150 W of power consumption, ranges are 230 and 140 km, respectively.

Although the goal of the *Typhlonus* vehicle was to implement a hull of extremely low drag resistance, the practicalities of using an AUV in real operations limit the design options. For these reasons, the *Typhlonus* hull is of more or less standard shape having small cylindrical insertion. Tests, both on the model and full-scale vehicles, indicated the hull resistance coefficient is 0.027-0.03 against V (where V =vehicle displacement) provided the Reynolds numbers begin at about 10^7 .

Another important element of the vehicle hydrodynamic structure is the thruster. In *Typhlonus*, a single propeller was used to obtain high efficiency both for the thruster and motor. At the same time, to meet the demands of satisfactory maneuverability at low

speed, a design was implemented that allowed the thruster axis to be moved both in the horizontal and vertical axes, thereby changing the direction of thrust. Design and testing of the *Typhlonus* suggested that the multi-thruster system is considerably simpler and more efficient with respect to vehicle maneuverability. The increased efficiency of a single propeller system is not obvious. The small hull resistance and resulting small thrust produced insufficient transverse forces with nominal vehicle velocity. As a result, foils were added to the turning section.

Tunnel Sea Lion AUV

In cooperation with a U.S. company, the institute developed an AUV focused on the inspection of long tunnels (Fig. 1.7, p. 9). The initial design concept was to develop an autonomous vehicle; further considerations led to a "long range ROV," an AUV with an optical tether cable to allow inspection using a video camera. The original vehicle had a standard thruster system. Initial testing resulted in modifying that design to include water jets for thrusters. This eliminated the problem of the thrusters cutting the tether when it was backing up.

AUV CONTROL SYSTEMS

For the most part, all of the AUVs developed by the institute have some similarities in their control systems. The vehicles are controlled by an autopilot unit which interprets program commands, interacts with all the vehicle electronic units, reacts to telecontrol signals, and triggers pre-programmed commands in emergency situations. Information exchange between the vehicle systems is realized over the common communication channel.

The vehicle orientation control system is more or less traditional. The movement control in horizontal plane is carried out through a comparison of data taken from a flux-gate compass, and program course set by auto-pilot. To damp oscillations, a rate gyro is included in the feedback circuit. A control channel in the vertical plane has two operating modes — auto depth or auto altitude. In the first case a programmed depth is compared with a depth-meter output; in the second, a feedback signal is produced by an echo-sounder. Signals from a pitch transducer and rate-gyro are also used. Transducer gains are chosen to achieve the optimal dynamic behavior of the control system.

Obstacle avoidance is implemented through the use of three sonar beams, one directed, one down, and one forward and at an angle of 45°. Obstacle avoidance is an integral part of the vertical plane controller. During bottom TV or photo surveys and detailed inspection tasks, the AUV moves at a pre-set distance from the bottom. The distance depends on the bottom relief, water clarity, bottom currents, and other environmental factors. This system has proven to be effective in most of the operations conducted, including those where the AUV was made to transit over large objects such as submarine hulls. The AUV *MT-88* software is capable of including an improved adaptive control system with spatial obstacle

avoidance. In the latest control system, a hybrid architecture, which is based on a hierarchy of network elements to increase the vehicle's survivability, is used. This is achieved in part by implementing a control system that is capable of reconfiguring itself. Some additional functions in software are directed at autonomous decision making.

Electronic hardware, naturally, went through several upgrades. In the mid-1980s a set of microprocessor boards, based on Russian CMOS ICs, were developed. These were used until recently. The latest modifications of the vehicles were implemented using WinSystems boards.

NAVIGATION SYSTEMS

A long base-line acoustic positioning system (APS) was designed for accurate positioning of the support ship and the vehicle with reference to bottom transponders. It is unique in that both the AUV and the support ship actively transmit synchronized sequences of acoustic pulses, thus allowing each to determine AUV position independently.

The vehicle on-board autonomous navigation system (BANS) includes a log, a compass, and a trim transducer and provides calculation of the vehicle location. Because of sensor errors, the precision of positioning goes down with time. In the *MT-88* an Integrated Positioning System (IPS) has been implemented which integrates the BANS data with data from the APS. In the *Typhlonus*, two inertial navigation systems have been developed: simple strap-down system and precise inertial platform borrowed from space shuttle technology. They are being used to support gravity experiments and the measurement of the structure of acoustic fields.

SENSORS

Due to the modular structure of the vehicles, it is possible to install different measuring equipment easily. Nevertheless, a standard set of instruments is included on all AUVs. These include temperature/conductivity sensors, side-scanning sonar with tape recorders, and a still camera. Other transducers such as gamma-radiometer and magnetometers are included when they are needed. Currently, work is underway to include a sensor for gravity measurements.

A NEW CONCEPT: THE SOLAR POWERED AUV

The institute at the present time is working on a solar- and wave-powered cruising AUV with unlimited range. The institute is currently conducting a number of investigations into various subsystems. Initial results suggest that a vehicle 1.2 m long, .5 m wide, and .22 m

in depth weighing from 20-50 kg with an optimal speed of 2 knots would allow 50 km transits during the nighttime hours. More work must be completed.

IMTP HYDROSTATIC TEST FACILITY

The entire panel visited the IMTP hydrostatic test facility and storage building. Older versions of AUVs developed at the institute, some no longer in use, were stored there. The hydro test chamber is unique in its test depth of 15 km (49,200 feet or 21,900 psi). The vertical chamber is .5 m in ID and will accept test articles up to 1.5 m in length. This allows IMTP to test all new pressure vessels to failure for validation of designs. In addition, all pressure vessels to be used in IMTP's AUVs are cycled to test depth before use. Originally, a single penetrator through the top allowed instrumentation of test articles. Over the years, the need for instrumentation has been reduced by the standardization of pressure vessels, and now simple go-no go tests are mostly conducted. Features of the facility include the following:

- Cylindrical construction with a plug type lid.
- The lid fitted with a single circumferential "O"-ring seal. The mechanical design of the lid incorporates a sliding piston that pressure-aids the seal for high pressure tests.
- An inert oil used for testing. All test articles are fluid filled to a very small implodable volume to preclude explosive collapse with damage to the chamber.
- The lid is retained, after installation by a yoke that rolls in place to constrain the chamber from top to bottom. This allows rapid test cycles and provides a simple, fail-safe closure mechanism.
- Overhead hoists are used to handle test articles and the chamber lid.

During our visit to the IMTP test facility we observed two vehicles of older construction that are now not in use. The *L2*, built in 1980, is an early AUV that has made numerous dives during its useful life. These at-sea operations included over 160 dives to depths greater than 4.5 km. *L2* was used to search for sunken Russian submarines in the Bay of Biscay at 4.5 km off Bermuda in 5.5 km and the *Komsomolets* off Norway in 1.7 km. A typical operation includes about one hour for descent, six hours of bottom time, and one hour of ascent.

The other UV observed was a towed device that was used in the initial location of the *Komsomolets* in 1989. Two of these towed vehicles were manufactured and assembled on board the support ship while underway to a deep water search operation. The two towed systems were made of modular components developed for the AUV systems.

While the team was at the institute, Dr. Ageev was asked to describe a few research issues that he felt were important at this time. The following research problems were identified:

1. The use of AUVs for marine gravity surveys (an extension of the *Typhlonus* project) and an experimental study and optimization of the control system to achieve very high motion stability, hence precise gravity measurement
2. Further development of integrated navigation systems for AUVs, including the use of sonar and video images
3. Investigations into long range/ long duration AUVs powered by solar and wave energy: energy, actuators, reliability, survivability
4. Development of intelligent control systems for AUVs tasked to accomplish real world tasks: survey and inspection of long, water-filled tunnels, underwater pipelines, and cables
5. Investigations of basic issues associated with deep diving (11 km) AUVs

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BACKGROUND

The Institute of Theoretical and Applied Mechanics (ITAM) was founded in 1957 by Academician S. A. Christianovich (he is 88 and lives in Moscow). He is one of the three original academicians who started the Siberian branch of the RAS, along with Lavrentyev and Sobolev. The staff numbers 600 (there were 1000 before Perestroika) of which 35 are professors and 180 are candidates of science. Staff reductions have been made mostly in support personnel; according to Prof. Fomin, scientists have nowhere to go. Attrition has been caused mostly by retirement and staff members moving abroad.

ITAM's main areas of work are mathematical modeling, aerodynamics, and physical gas dynamics. Note that the institute has done continuous aerodynamic work for more than 30 years. Half their budget comes from the RAS. They have to earn the other half. This comes from the Russian Foundation for Basic Research and from contracts with different firms: American, European, Italian, and those of the former Soviet Union. "We are learning to make much money working with foreign firms."

- ITAM is traditionally the best institute in the countries of the former Soviet Union in fundamental aerodynamics; but it is difficult to compare their facilities with the Central Aerodynamic Institute (TsAGI — Russian acronym), the Institute of Missiles, etc., ostensibly for larger-scale, more mature work. In the past, all Soviet aerospace design firms worked with ITAM, because ITAM had the ability to develop future projects. The new Russian aerospace thrust is focused only on the present. Currently, Russian military and commercial contracts are practically non-existent at ITAM.

- The institute has eight wind tunnels, of varying sizes and capabilities, all of which are computer-controlled. Their wind tunnels cover a wide range of realistic conditions, though the range is not complete. They are working on designing a new generation of wind tunnels, collaborating with the United States. They recently hosted a delegation from Princeton University to discuss this work.
- They are developing a LAN to link facilities. This is necessary because their old central computer has been replaced by PCs.
- They have contracts with Aerospatiale and Dassault (France); Germany; Boeing and Rockwell (USA) — doing both experiments and joint projects.
- They used to work with all the universities and institutes in Russia; they now work more with foreign design institutes. Traditionally, they have interacted more with foreign academia than foreign firms, but this is changing.
- They are active in international conferences and have, in fact, joint publications with western scientists in AGARD, the American Space Agency, and Soyuz Applied Science.
- Regarding patents and copyrights: They know what's going on, as in the meaning of proprietary.

The institute has two teaching departments, one at Novosibirsk State University and the other at Novosibirsk State Technical University. They have started having third year students take practical instruction at the institute. Their goal is to fight current trends: There are more students, but fewer aspirants and scientists. Young people go through their studies, get a little experience, and then go overseas to work. The average age of their staff is now about 45 years, but they are able to keep 10 to 15 aspirants per year. Figure 2.15 shows the institute's view of its activities and capabilities.

RESEARCH & DEVELOPMENT

Aerodynamic Research

Figure 2.16 shows, graphically, the distribution of Reynolds and Mach number capabilities among ITAM's eight wind tunnels. Table 2.3 lists the operational parameters of ITAM's wind tunnels.

They have a large tunnel where they can get high Mach numbers but not high Reynolds numbers — they are striving to get clear flow and high temperature. They are working on understanding the differences between a stationary object in a moving air stream (interactions with the wind tunnel's wall) and a moving object in stationary air. This will lead to more realistic test conditions.

The Institute was founded in 1957 by a prominent scientist in the field of theoretical mechanics, Academician S.A. Christianovich. Subsequently, the Institute was headed by Academicians V.V. Struminskii and N.N. Yanenko - outstanding scientists in aerogas dynamics. By now, the following three lines of investigations have been formed:

- mathematical modelling in mechanics;
- aerogas dynamics;
- physical gas dynamics.

Following these lines, the Institute performs a wide program of investigations aimed at solving such large comprehensive problems as:

- creation of computer codes for modelling continuum mechanics problems; nonequilibrium flows and plasmas; interaction of multiphase and reacting flows with solids;
- development of scientific foundations for monitoring aerodynamic characteristics of bodies when flown around by sub- and hypersonic flows. This line involves: complex turbulent flows in gasdynamics problems; outset of turbulence; methods for monitoring turbulent layers; optimization of aerodynamic configurations of flying vehicles and their elements; change in the wave structure of flows using external combustion and blowing out one- and two-phase jets; methods and means to simulate transonic flows;
- Dependability of economical and ecologically pure power and propulsion installations (efficient techniques for energy conversion based on flows with chemical transformations and heat mass transfer; thermal protection of transport and power facilities in extreme conditions).

Fig. 2.15. Brief outline of the Institute of Theoretical and Applied Mechanics, RAS, Siberian Branch (Novosibirsk, Russia). [Retyped verbatim from the original.]



Fig. 2.16. Distribution of Reynolds and Mach numbers.

Applied Aerodynamic Research

This is in the areas of reducing aircraft aerodynamic resistance; specifically, they are working on control of the laminar-turbulent transition by reducing cross-flow through management of separation phenomena. They are able, through the influence of riblets, to control the boundary layer transition.

Research on Hydrodynamics

The institute performs experiments and mathematical modeling in hydrodynamics. They supported hydrofoil work in conjunction with an institute in Irkutsk and wing-in-ground effect work (Ekronoplan) with an institute in Nizhny-Novgorod.

Table 2.3
Main Characteristics of Wind Tunnels at ITAM

Code	Type	Test section size (m)	Mach range	Stagnation pressure, atm	Stagnation temp., °K	Max. Reynolds number/m	Running time	Reference
T-324	closed circuit	1 x 1	0.03 - 0.3	~1	300	3×10^6	60 min	low turbulent
T-334	closed circuit	0.62 x 0.62	0.3 - 1.2	up to 9	80-300	3.5×10^8		under construction
T-313	blow-down	0.6 x 0.6	2.8 - 6.0	12	up to 700	6×10^7	5 min	
T-325		0.2 x 0.2	0.5 - 4	12	300	2×10^7	10 min	
T-326		0.2	5 - 14	120	up to 1500	4×10^6	1 min	plasma heating
T-327	with vacuum capacity	0.22	16 - 25	200	2500	2×10^5	40 s	nitrogen
T-333	blow-down	0.3	2 - 5			5×10^7	10 min	
UT-302	hot shot	0.3	5 - 15	1500	3000	$\sim 10^8$	120 ms	

Cold-Gas Dynamic Spraying Method (video)

They use low temperature and high speed (the process may be amenable to mass production). In their apparatus, powder is sprayed at 77-800°F (at a temperature lower than the particular powder's T_m) onto the object to be coated. The particle size is typically <1 mm. Due to the low temperature, the coating's properties are similar to the properties of the particles because there is no melting or outgassing.

- This process doesn't need a plasmatron or a detonation gun; it uses a gas heater and a supersonic nozzle.
- Operational coating parameters: air pressure is 100-300 psi at 1 m³/min; $T_{jet} < 300^\circ\text{F}$; coating thickness is typically 1-15 mm, but thickness is practically unlimited.
- We saw an example of aluminum coated onto a steel tube: the coating appeared to adhere very well and to be quite uniform. We also saw a re-bar coated with aluminum and covered with a vinyl coat.
- They noted that the surface doesn't need any special preparation.
- The process can weld dissimilar materials and be used to bond unweldable materials such as glass and ceramic.

- Demonstrated coatings: zinc onto glass; aluminum on copper (high concentration); copper onto duralumin; zinc onto ceramic; aluminum onto copper (high concentration — it looked like spikes about one inch high).
- The process can be used to coat on both outside and inside diameters.
- They suggested coating ships instead of painting them.
- We brought up the possibility of using this process for fast-prototyping (notably in the auto industry).
- They noted that the physics of this coating phenomenon are not well understood. (See Papyrin, undated, for further description.)

Solid Rocket Motors

They have designed sub-launched solid rocket motors, though they are now being destroyed under arms reduction agreements. They showed an internal ballistics trace: the rocket has a burn time of about 2 seconds (a short burn time for such an application) with no trail-off and a maximum pressure of 60 atm. Its burn was neutral with a long pressurization period.

They designed a telescoping nozzle for this rocket, ostensibly so it could fit in its launch tube while maintaining decent performance. It appeared that in operation (fully extended) it would be capable of submergence.

Self-Forging Projectiles

They model explosive performance and performance of self-forging projectiles. They claim good results in modeling penetration of self-forging projectiles through metal plates (at $v = 4\text{-}5$ km/sec).

Marine applications: mathematical modeling of body movement in salt water.

They work with the Japanese on magnetic reduction of hydrodynamic drag, using mathematical models only — experiments are expected soon.

WIND TUNNELS TOURS

On our walk to the first of the wind tunnels, we saw an accumulator farm composed of 80 tanks, each approximately six feet in diameter and 60 feet long; the stated pressure capability of each tank is 16-20 atm. Two photographs of this tank farm are shown in Figure 2.17.

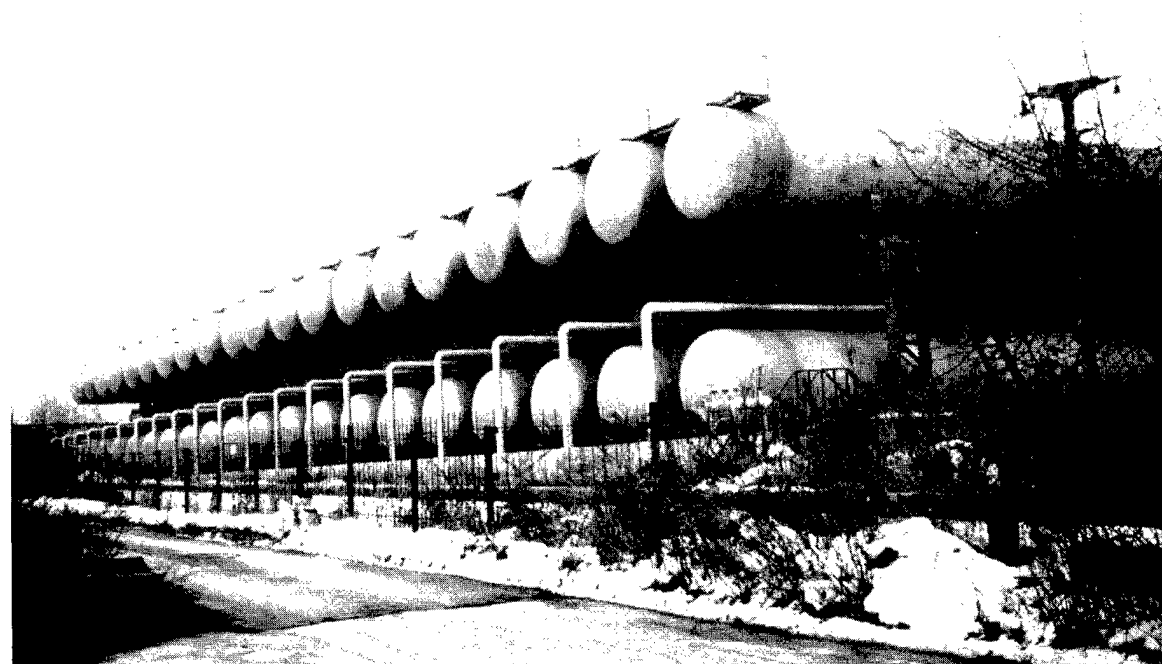


Fig. 2.17. Wind tunnel accumulator tank farm.

UT-302 Wind Tunnel

Operational parameters: Mach capability 5-15, maximum pressure 100 atm, 3000°K temperature capability with an event length 50-200 ms. This tunnel is different in principle from others because it has flow stabilization.

- Combustion test rig. They run Mach 5-6 engine combustion tests in the UT-302 tunnel using hydrogen and acetylene for fuel. They measure -OH to determine the extent of combustion.
- They also have a model of a hypersonic missile engine which has been tested at Mach 10-13, burning hydrogen. It is unique because its combustion chamber has a non-traditional design.

Supersonic Experiment Facility, Wind Tunnel T-313 (*Prof. Kharitonov*)

The test area of this tunnel is 0.6 by 0.6 m. It operates up to Mach 4 with cold air and Mach 5 & 6 with heated air. The tunnel has a 5-6 minute test duration. We saw a model set up with two wedges in the test section to measure Mach reflection. In the demonstration we could see, on a TV monitor, the streamlines and Mach stem forming with changes in the wedges' positions.

- They study the fundamental science of complex turbulent flow and shock interaction and bonding.
- Prof. Ivanov is studying the transition from regular reflection to Mach reflection. This is important for the inlet problem; one must determine the parameters of the transition taking into account hysteresis effects.
- They use four component balances to measure air pressure around the model.

Hypersonic Wind Tunnel, T-326

They use this tunnel to measure heat flux on reentry bodies. The Mach capability is 5-14 in a test chamber measuring 60 cm. They use a plasma heater above Mach 8.

Supersonic Hydro Wind Tunnel, T-325 (*Dr. Kosinov*)

They use this tunnel for laminar/turbulent flow measurements in the range of Mach 2-4.

- They use artificial disturbances (in the set-up we saw, there was a barely discernible nub on the wedge test item) of the boundary layer to test linear stability theory; they have been doing this research for the past two years.
- They are beginning to test non-linear stability theory, noting that the interaction of waves in the boundary layer is not fully described by the theory.

- They also perform research on cone shapes, supersonic wakes, and the stability of the 3-D boundary layer.
- They are measuring wake characteristics from artificial disturbances; they also study the effects of a 20 kHz spark discharge disturbance.
- They use a 3-D traversing hot-wire anemometer in this tunnel.
- Overall: they are looking for the transition from instability, not for the means to control it.

Large Wind Tunnel, T-324 (*Prof. Kozlov*)

Prof. Kozlov showed us this tunnel. The velocity range is a fan-driven 1-100 m/sec to provide a laminar, very good quality flow. The working chamber is 1 m by 1 m, and the tunnel is made of wood to prevent acoustic noise (yielding a signal-to-noise ratio of 10,000).

- They study the physics of laminar/turbulent transition and separation and measure the high free-stream turbulence level, in the Klebanoff regime, using a grid.
- Influence of riblets for laminar/turbulent transition: the scientists can affect the turbulent boundary layer transition with riblets, but still can't explain all of the physics involved. They, in fact, use riblets to affect control with positive results. They have found that streamwise riblets show improvement when compared to smooth airfoil and transverse riblets. Note: l-structure riblets work well.
- For cross-flow instability, riblets can improve swept-wing performance, but riblets on the whole wing don't work. They use the formula that the riblet height should be about one-third the thickness of the laminar boundary layer.
- Engines: they study other laminar/turbulent transitions, for example the vortex effect in boundary layer (a new type of disturbance). They have had success in controlling this — they published their first results in 1984. Though, as stated above, they don't understand all the physics of riblets, they understand them well enough to improve control.

Hypersonic Wind Tunnel, T-327A

This tunnel uses a nitrogen working fluid at 13°K; the tunnel also incorporates a nitrogen cleaner. The basic operating parameters are Mach 16-24 and a Reynolds number of $\sim 10^5$; they simulate altitudes of 80-90 km and use temperatures up to 2000°K. The tunnel's vacuum system has a volume of 100 m³. They use a three-component test balance to measure drag, lift, and pitching moment. Other measurements include heat flux, temperature, velocity, and vibration. They also use an electron beam to measure density and to visualize flow. Operating time is 1 minute.

We saw a model of their Buran space shuttle orbiter in their collection of test shapes.

INVENTIONS

Consumer Fan/Refrigerator Device (for lack of a better name)

This device is also capable of separating 1 mm dust (as an air cleaner). It could also be used as a dehumidifier, and it could be used to separate fluids of different densities.

- It is patented in the United States and elsewhere.
- They claim taxes to produce it in Russia are low, while the cost of importing it to Russia would be high.

Wind Engine

We saw a video of their unique wind engine: it starts with wind of 2 m/sec. The blades were similar in operating principle to the sails of Cousteau's wind ship.

SUMMARY

The director and staff of this institute exude vigor. The WTEC team came away with the impression that they are self-sufficient or are certainly heading towards self-sufficiency. They seem to be strong not only in the quality and number of their international contacts, but also in how they are regarded as a leader in aerodynamics research not only in Russia, but in the international community.

While a visitor naturally gets overwhelmed by the extent of their aerodynamics work and facilities, one should not dismiss the institute's other scientific capabilities, which we have unfortunately only touched upon in this report.

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Leonid I. Maltzev, Head, Applied Hydrodynamics Lab.

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N. V. Malykh, Research Scientist

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BACKGROUND

The Institute of Thermophysics of the Siberian branch of the Russian Academy of Sciences was founded in 1957 as one of the first research institutions of the Novosibirsk Science Center (Akademgorodok). To date it has had three directors; the current director is Academician V. E. Nakoryakov. The institute has a staff of 600, including 200 scientists, approximately half of whom are Ph.D.s, and two academicians. It consists of 10 major departments, comprising 40 laboratories. Its present funding is close to \$1 million per year, only a small percentage of this coming from the state.

The Institute of Thermophysics is considered one of the best research institutions in Siberia, perhaps in Russia. It is rated as one of the top three of one hundred Siberian research institutions. The rating is based on the number of scientific papers published, the amount of non-government funds obtained, and the relative number of young personnel on its staff (the average age was quoted as being 40 years).

The major research areas of the institute are the following:

- Heat-mass transfer
- Turbulent single phase and gas-liquid flows
- Vortex flows
- Drag reduction for underwater vehicles
- Radioactive and combined heat transfer
- Dynamics of internal waves
- Plasma dynamics
- Rarefied gas dynamics

The research is supported by an extensive inventory of experimental equipment — including wind tunnels, hydrodynamic tunnels, cryogenic test facilities, two phase systems, etc. They also have access to a test facility for hydrodynamic research on Lake Issyk-Kool in the newly-independent state of Kirgisia. A similar facility on the Black Sea (Sevastopol) is now under Ukrainian control, unavailable to the Russians.

The main focus of their industrial (applied) work is heat absorption pumps, which is a major source of income for them (~\$3.5 million in Russia). They have contracts with diverse national and international companies, including three with U.S. companies. They have a contract for \$600,000 in 1996 for the company Air Products, located in Pennsylvania, to develop cryogenic equipment to produce oxygen by compression and liquefaction. On a small contract (~\$100,000) they developed a color jet printer for Hewlett-Packard. The soldering technique, which they developed in only two months, is being patented with another small contract. With General Motors, they developed automobile heat exchangers to remove condensation from under the hood, thereby reducing the problem of corrosion.

RESEARCH AND DEVELOPMENT ACTIVITIES

During our visit, several researchers, mainly from the Applied Hydrodynamics Laboratory, provided detailed presentations of their work. Much of the research discussed concerned the various approaches to the reduction of drag and noise of underwater vehicles, although hydroacoustics, wakes, vortex technologies, and heat pumps were also touched upon.

Drag and Noise Reduction of Underwater Vehicles

Much effort, involving several researchers, has been devoted to this area, as evidenced by the following list.

Supercavitation (L. Maltzev, L. Guzevsky, B. Novikov)

The Maltzev group has investigated cavity methods of drag reduction and jet control using supercavitation. The cavitation around a body and the stability of the flow was investigated for different Froude numbers and cavity geometries. It was found that instability was reduced when the body geometry was fitted to the geometry of the cavity. Instability was also reduced when water was injected around the cavity boundary using jet methods. These methods have been applied to control the characteristics of hydrofoils and rudders. In particular, a liquid jet introduced tangentially to the suction side of the foil reduced (by a factor of five) the instability, greatly increased the lifting forces, and reduced the drag. L. Guzevsky has developed a numerical method for determining a wide range of planar and axially symmetric cavity flows of ideal fluid.

Injection of Gas Bubbles into the Boundary Layer — Gas Bubble Saturation (L. Maltzev, A.G. Malyuga)

It is well known that saturation of the fluid boundary layer by gas micro-bubbles can cause skin friction drag reduction. Maltzev has investigated methods of injection of a thin layer of air or an air-water mixture between a ship and its water boundary layer. Instead of injecting gas through porous sections (the customary method), the fluid boundary layer was saturated with micro-bubbles using jet methods of gas injection through a slot. The jet methods were found to have advantages compared with the injection through porous materials, particularly for long, axi-symmetric bodies.

Injection of Polymer Additives (V. Kulik, B. Mironov, B. Semenov, V. Mamonov, A. Malyuga)

It is well known that the addition of high-molecular polymer additives into the near-wall flow reduces drag (Tom's Effect). The group has conducted investigations into various aspects of Tom's Effect, including the effect on turbulent flow of super-molecular structures in polyethylene oxide (PEO) solutions and the effect of aerating (gas bubbles) the high-polymer solution. The researchers demonstrated that in solutions of high-polymer PEO, the destruction of super-molecular structures leads to a minimization of turbulent friction and to a decrease in the mechanical degradation of polymers in the flow. They also concluded that aeration of polymer solutions increases their efficiency. Since storage of polymer material in fluid form is not practical, they have developed effective methods of storage using dry polymer pellets. The polymer solution is prepared by adding water to the pellets; the process then takes seconds to form the solution. These fast-made polymer solutions are more effective and practical than pre-prepared polymers.

Compliant Coatings (B. Semenov, V. Kulik)

The group has conducted investigations into the effect of viscoelastic coatings on the reduction of turbulent boundary layer friction. Studies in this area are at least several

decades old and have involved investigations from a number of countries, particularly the United States. The possibility of turbulent drag reductions by compliant coatings apparently first arose from the assumption in bionics that the dolphin's deformable skin allows it to greatly minimize turbulence, even at high speeds. The majority of subsequent studies was carried out on passive coatings, the surface deflection of which is the result of the action of the pressure pulsations of the turbulent flow. In spite of the many earlier investigations, the "physics of coating" was not well understood, and the results were often inconsistent. In large part, the preceding is explained by the fact that many of the earlier experiments failed to characterize the viscoelastic properties and vibration characteristics of the coating materials accurately. For example, the properties were measured only at a single resonance frequency, or over a very narrow frequency band. Further, the general explanation for coating-induced drag reduction, viz. Kramer's hypothesis of energy absorption, could not explain the increase in friction occasionally observed.

Because of the preceding, Semenov, Kulik, et al. conducted systematic experimental and theoretical investigations of the correlations among one-layer viscoelastic coatings and turbulent friction and wall pressure fluctuations. Their studies validated the interference theory of viscoelastic boundary action on near-wall turbulence and also established a number of useful quantitative criteria for the effective performance of drag-reducing coatings.

Laminarization of Boundary Layer

At high Reynolds numbers, laminarization of a boundary layer though the wetted surface results in a significant decrease in total drag, roughly by an order of magnitude. However, at high Reynolds numbers a transition occurs from laminar to turbulent flow. Novikov et al. conducted extensive work in a laboratory wind tunnel and also with towed models in the field in the area of laminarization of a boundary layer via the suction of water through perforated surfaces. Tests were carried out on small-scale perforated shells of models at Reynolds numbers of 1.7×10^7 and 10^8 . The scientists were able to attain a stable, asymptotic, coordinate-independent boundary layer and to achieve marked decreases in both the total and effective drag.

Hydroacoustics

The research efforts in two main areas of hydroacoustics were presented during our visit: ultrasonic synthesis of HPC and shock wave suppression by bubbles.

Ultrasonic Synthesis of HPC (N. Malykh)

Because of their unique properties, heteropolycompounds (HPCs) have numerous practical applications in a number of fields, including analytical chemistry, clinical medicine, electronics, the production of phenole, 2-propanole, 2-butanole, etc. Consequently, Malykh and his colleagues have been investigating alternative methods of synthesizing

HPC using ultrasonics. Present methods of HPC production are lengthy (up to 20 days and nights), require power-intensive equipment, and produce wastes (salts of sodium and acids). The method developed by Malykh et al. is based on the effects of nonlinear ultrasonic cavitation on solutions containing solid additives. In particular, metal oxide particles are crushed by shock waves and cumulative microjets at the collapse and resonance frequencies of vapor-gas bubbles on and near the particle surfaces. Along with the crushing, heating, and mixing, activation of the reagents occurs during the cavitation and associated processes. The method developed results in reduced processing time, removes ecologically harmful wastes, and uses less energy.

Shock Suppression by Bubbles (N. Malykh)

Traditional methods of protection of structures against shock waves are generally based on either the use of sound absorbing materials or on the reinforcement of the structures. Malykh has investigated an alternative approach, using a shield of bubbles that act as a barrier against the shock wave. The bubbles greatly reduce the amplitude of the incoming shock wave by, in essence, absorbing its energy at bubble resonance. In reality, the process is somewhat more complex, involving nonlinear pulsations of the bubble. Malykh has demonstrated that the effective thickness of the bubble layer depends upon the duration and amplitude of the shock wave and the parameters of the layer (gas concentration, bubble sizes, and the bubble void fraction within the layer).

Vortex Technologies (*Alekseenko, Okulov, etc.*)

In the area of turbulence research, an important goal is the understanding of coherent structures (or organized motions). It has long been known that turbulence in shear flows is not a purely stochastic process but includes numerous well-defined structures whose formation and evolution depend strongly on the interaction and decay of vortices at various scales. Interest in these structures derives, in part, from their fundamental importance, not only in hydrodynamics, but also in other branches of natural science. Further, these structures are the basis of many phenomena and applications in swirling flow technology.

Alekseenko, Okulov, and their colleagues have conducted numerous experimental and theoretical investigations of vortex structures, particularly swirl flows. Swirl flows are widely used to intensify heating, energy separation, and mass transfer in power machines, such as tangential flow combustion chambers, cyclones, centrifugal burners, etc. The physical mechanisms of swirl flow and their associated applications are as follows:

- Creation of more intensive centrifugal than gravitational acceleration. This is used for separation processes.
- Prolongation of particles' path. The total path length traversed between two points by particles moving helically about an axis is clearly greater than the rectilinear path

length along the axis. This greater path length results in intensification of heat and mass exchanges, chemical reactions, and combustion.

- Formation of recirculation and reverse flow zones. This enables gas rarefaction and flow stabilization.
- Ranque effect temperature separation. Used in heat and cold generation processes.

Among the large-scale vortex structures examined by the Alekseenko group are the following: the rotating helical vortex, the stationary rectilinear vortex, the stationary right-hand helical vortex (screwed along the flow rotation) and left-hand vortex (screwed contrary to the flow rotation), double stationary helical structures, and the stationary vortex with transition from the right-hand helical symmetry to the left-hand one. Their investigations have included the first observation and description of a steady-state, two-spiral structure of interacting vortex filaments of common sign. Figures 2.18 and 2.19 show a number of the vortex structures studied by the group.

Heat Pumps

Heat pumps are used for the production of hot water for space heating, for heating and cooling technologies in power generation and other industries, and in other applications. The Institute of Thermophysics has performed extensive studies in this area and, as already noted, heat pumps form the focus of their industrial work. Particular emphasis has been placed on Absorption Lithium Bromide heat pumps (ALHP) and transformers (ALHT). They have also investigated environmentally friendly fluorocarbons, R-236 and R-227, as working substances in heat pumps and refrigerators. Since these substances are inactive with ozone, non-toxic, and chemically inert, they are safe substitutes for Freon.

SUMMARY

The Institute of Thermophysics is one of the leading research institutions in Russia. Like most of the other research institutions, its funding has been adversely affected by Perestroika. However, they have demonstrated a surprising degree of entrepreneurial initiative by successfully marketing their products and capabilities. At present, only a small percentage of their annual budget is provided by the government. Since our visit, the institute has submitted proposals to continue research in six of the areas discussed in this site report to the U.S. Office of Naval Research.

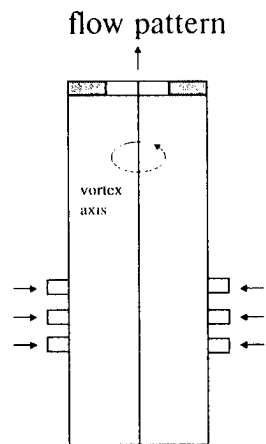
The institute has extensive experimental facilities and equipment but suffers from the lack of modern equipment which is expensive to purchase abroad. They have a good local computer network (HP equipped) and an impressive publishing capability. Their work has been reported in a substantial number of English publications.

1. rotating (precessing) helical vortex

location of precessing vortex core at chamber cross-section for two time moments



2. rectilinear vortex



3. right-hand helical vortex (vortex is screwed according to flow swirling)

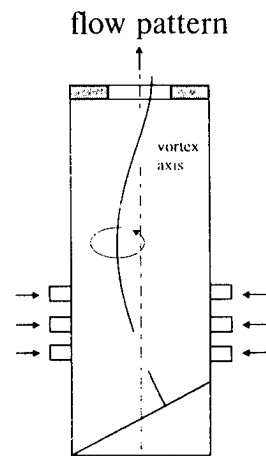
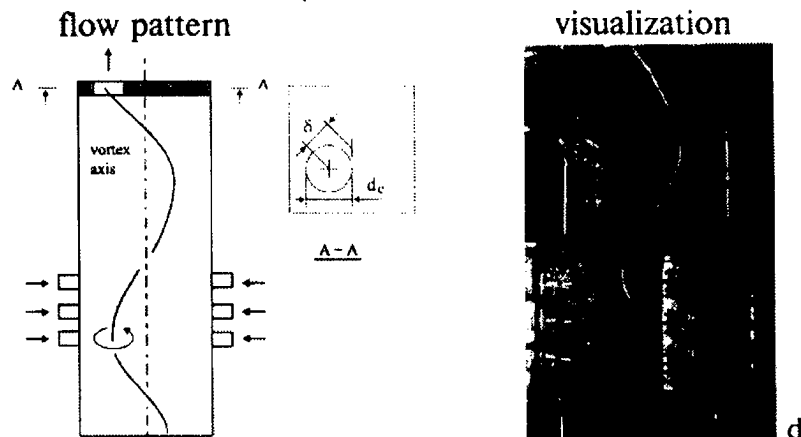
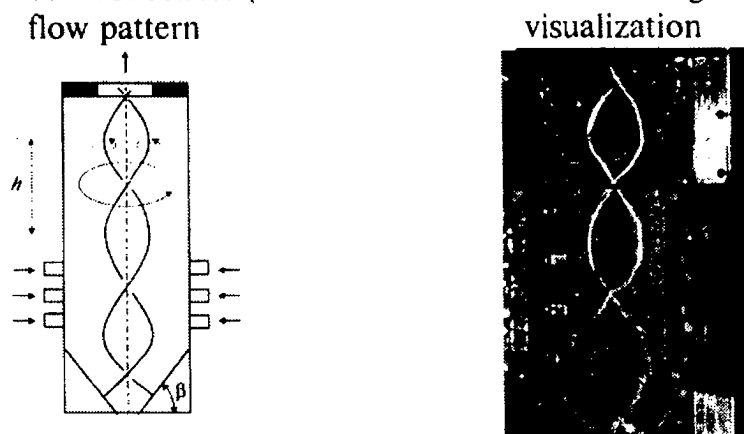


Fig. 2.18. Vortex structures studied (a).

4. left-hand helical vortex (vortex axis is screwed backward to flow swirling)



5. double helical vortex!!! (vortex axes are screwed according to flow rotation)



6. vortex with change of helical symmetry !!!

(near the bottom the vortex axis is screwed according the flow swirling, but at the top part it is screwed in the opposite direction)

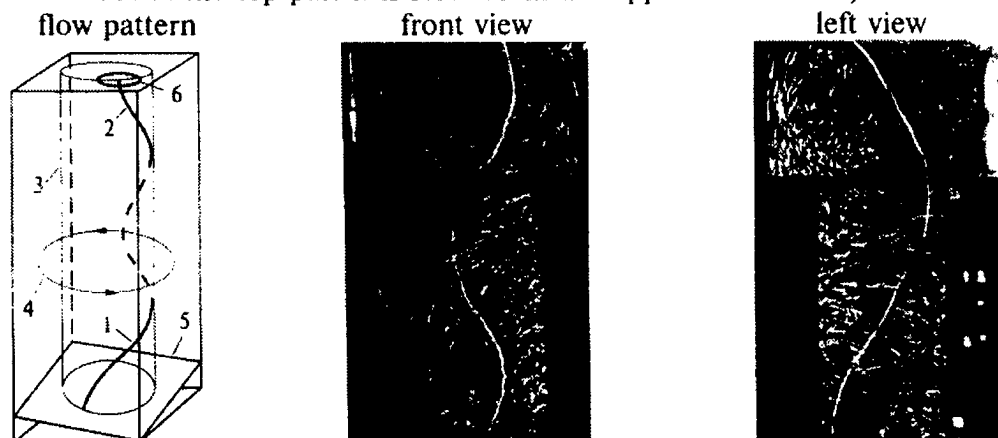


Fig. 2.19. Vortex structures studied (b).

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Prof. Valery K. Kedrinskii, Vice Director
Prof. Vladislav V. Mitrofanov, Head, Detonation Processes Lab.
Prof. Victor I. Bukreev, Head, Experimental Applied Hydrodynamics Lab.
Prof. Izolda V. Sturova, Head, Wave Hydrodynamics Lab.

BACKGROUND

The Lavrentyev Institute of Hydrodynamics (LIH) was the first institute founded at the Akademgorodok (Academic City). The LIH was founded in 1957 by Academician M. A. Lavrentyev with three immediate goals for the Akademgorodok: development of the main research directions, establishment of active relations between science and industry, and training of young research fellows for advanced science and engineering.

Research Fellows of the LIH head four chairs at the Novosibirsk State University: Hydrodynamics; Theoretical Mechanics; Continuum Physics; and Solid Mechanics. Approximately 500 people are employed at LIH, including 170 scientific personnel. The scientific staff includes 130 to 140 Ph.D.s, 43 doctors, three academicians, and two corresponding members of the Russian Academy of Sciences. LIH is the founder and publisher of three scientific journals with international distribution: *Combustion and Explosion Physics*, *Applied Mechanics and Technical Physics*, and *Continuum Mechanics*.

The institute does fundamental and applied science in the areas of mathematical problems of continuum mechanics, applied hydrodynamics, solid mechanics, and detonation and explosion processes.

Director Titov gave an overview of the institute and introduced heads of various laboratories where he felt we might have an interest. During his opening remarks he made the following points.

- He briefly introduced the work of the applied hydrodynamics laboratories and their work in stratified flow and dynamic flow (i.e., turbulence, internal waves, shock and acoustic wave propagation in water and bubbles, etc.).
- He spent some time discussing their work in hydrodynamic flow without gravity and described the importance of capillary forces and crystallization and melting in non-gravity conditions.
- He emphasized the duality of their balanced work in both the theoretical (e.g., numerical modeling) and experimental (empirical testing) areas.
- Early on the institute focused on theory and the work was moved to other institutes for transition to commercial applications. At this time they do more applied work, but they still stop short of commercial development.
- He likened their capabilities to the U.S. Navy's David Taylor facilities although with significantly fewer test facilities.
- Before Perestroika the staff was slightly larger, but with reduced funding they have lost administrative staff while the scientific staff has remained relatively constant. Some of the scientists are working abroad, and most of the technical people who have left were engineers rather than scientists.
- Much less income is now coming from the Russian government. More is coming from an increased number of contracts with international institutes and companies. They have contracts with a wide range of foreign interests, much in Korea and the western United States. They have none as yet with South America, Australia, or Africa.
- Prof. Titov was asked if their work in explosive forming has been successfully transitioned to industry. He commented that he had a recent visit by personnel from Sandia Laboratories asking to be "taught" how to convert to industry. From the beginning Academician Lavrentyev's position was that "weapons are all right, but we need to do work for useful endeavors."
- He was asked if they have done much with non-linear hydrodynamic flow regimes. His answer was that they have done some work in shallow water phenomena.
- Titov was not terribly responsive to the prospect of proposing funded research projects to the West. He indicated that they have had little experience in preparing work proposals. They want to keep their focus at home for the benefit of Russia. If entities in the West can see areas of joint interest in the work they do, LIH will be willing to discuss cooperation. He also implied that they were not willing to take under-priced development work just to get a few dollars. The days of cheap scientific labor at the institute were over. He also said they have no military funding at present and they were more interested in basic research than defense research. They want to remain focused

on theoretical work and if serendipitously something can benefit industry that is acceptable. It wasn't clear his staff felt the same about these issues.

RESEARCH AND DEVELOPMENT ACTIVITIES

Two of the institute's areas of research were described in detail: detonation processes and applied hydrodynamics.

Laboratory for Dynamic Loading of Condensed Matter

Prof. Igor V. Yakovlev described the work of this laboratory. The institute has a widely varied effort in fundamental and applied research in explosive working of materials and high-velocity processes. These activities include numerical simulation and experimental study of detonation and shock wave flows and deformation and failure processes under impulse loads. The institute has a long history of experience in explosive working of materials including hardening, welding, compaction, forming of structures from powders, and detonation spraying. Some of these processes and the resulting products were described and shown to us. We also visited two laboratories. One was outfitted with a variety of explosive containment chambers for experiments in materials forming and welding and the other for detonation spraying.

Explosive *welding* processes, involving melting and fusing of metals, have been developed at the institute for over 30 years, and many techniques are now used commercially in Russia to form metallic and bi-metallic structures where high strength and low cost is desired. Also, special bi-metal welding processes have been developed for unique applications such as components for reduced galvanic corrosion in ship systems.

Hardening is different from welding in that explosive mechanical deformation is used to harden 1 to 2 mm thicknesses of the surface. Their work in hardening has been transferred to a Novosibirsk factory where large chambers capable of accommodating 2-3 kg of explosives are operated.

They also have developed an explosive *liquid extrusion* process for forming plate, which was not described to us in any detail.

Compaction is another process they have developed, especially in bonding of metals to non-metals such as copper to ceramics where special electrical conductive and isolation characteristics are required and in swaging of cables to fittings using primacord. Explosive compaction devices have been used extensively in the electrical cable industry in Russia.

Explosive *forming* of metal and ceramic matrices is also an area of research at the institute. Metallic or ceramic powders are compacted in a 2-3 microsecond impulse that does not change the properties of the powder. This process can also be used to form metal

structures with embedded composite fibers or metal alloys consisting of small spheres. They have a contract with Dynamit Nobel relating to this last process.

Detonation Processes Laboratory

Prof. Vladislav V. Mitrofanov, Head of the Detonation Processes Laboratory, presented its work.

Detonation spraying is one of their important developments over the past decade. We were shown a laboratory demonstration of the technique which involves deposition of a thin film of powdered coating on a parent material by a microwelding process. The powder is thrown onto the target object by a mixed-gas automatic detonation gun (ADU "Ob") at velocities of 1500 m/sec and temperatures of about 4000°C. Detonation pulses of up to 6 shots per second apply coatings of up to 10 microns of thickness per shot. The powder is melted and firmly bonded to the surface on a molecular level. A variety of coatings and parent materials are used to achieve desired characteristics of precise thickness, hardness, wear-resistance, corrosion/erosion protection, etc. This process is a cost-effective technique for restoring worn parts to full reusability. Typically the gun is fixed, and the target position may be computer controlled to apply the coating where desired and in thicknesses required. The patented coating technique has resulted in more than 20 "Ob" units in use in various Russian enterprises and research institutes.

The fundamental research in explosive processes at LIH is considered of the first rank in Russia, and they have a number of industrial investigations going on with companies in Sweden, Japan, Germany, the United States, and Yugoslavia as well as in Russia. In their research they have used many different kinds of explosives to achieve a variety of loading rates, pressures, and temperatures for their processes in high velocity processes.

Department of Applied Hydrodynamics

The activities of the LIH in applied hydrodynamics cover the gamut from mathematical analyses of fundamental hydrodynamics to their application to very practical problems. The activities of the Laboratory of Stratified Flow and the Laboratory of Experimental Applied Hydrodynamics include: stratified and turbulent flows, wake characteristics, surface and internal wave generation mechanisms, the effects of waves on submerged bodies, and experimental testing of mathematical models and numerical computations in hydrodynamics.

Laboratory for Wave Hydrodynamics

Prof. Izolda V. Sturova presented some of their work on the motion of submerged objects in a stratified flow, particularly regarding the role of internal waves. The practical importance of this subject arises from the extensive development of underwater vehicles, submersibles, and offshore structures. When a body moves in a stratified fluid, it

experiences hydrodynamic loads which are affected by the density variation. The dynamic interaction between the floating body and the stratified fluid includes a transfer of power from the body into the generation of internal waves. This leads to the well-known phenomenon of "dead water," studied by Nansen and Ekman at the end of the 19th century.

The group at LIH led by Prof. Sturova has conducted experimental and theoretical investigations of this problem and developed methods for calculating and studying surface and internal waves generated in different stable fluid stratifications. The experiments involved measurement of hydrodynamic loads due to internal waves on a restrained sphere located either below or within the pycnocline (the region of density change). The theoretical analysis, using the coupled finite element method, was based on the 2-D linear problem of radiation and scattering of small-amplitude surface and internal waves from a horizontal cylinder moving at a constant depth below the pycnocline. Previously, the problem of a submerged body advancing in regular water waves had been considered only for surface waves in a homogeneous fluid. The pycnocline variations were modeled by 2- and 3-layered fluids. In part, the experiments were designed to establish the limits of the theory, since the theories are linear, while the phenomena are non-linear.

Laboratory of Experimental Applied Hydrodynamics

Prof. Victor I. Bukreev, head of the Laboratory of Experimental Applied Hydrodynamics, provided an overview of the type of work being performed in his laboratory. He noted that the lab, which was organized 35 years ago, has solved 200 problems — which he classified as either "fundamental problems" (initiated by his lab) or "applied problems" (originating externally). Most of the relevant experiments were conducted in laboratory conditions; however, six of them involved large-scale field investigations. The work has included joint projects with many groups in other cities of the former Soviet Union. Also, they have contracts with Russian companies and even with some American companies. As examples of the latter, Bukreev cited the development of a water-jet tank cleaner and a humidifier for American companies.

Much of the work of the group revolves around the areas of experimental investigations of wave motions, hydrodynamic stability and turbulence, and the motions of bodies in liquids. Bukreev mentioned several examples of the preceding, including the study of the effect of internal waves on a body. Unlike the work of Prof. Sturova, this was concerned with problems of the stability of the body, including an analysis of its pitch, heave, and roll. The forces acting on a stationary body (cylinder) were also investigated, since this body is used to study wave impact on fixed marine structures.

Bukreev provided some examples of innovative, in some cases even ingenious solutions to diverse problems. He was particularly enthusiastic in his description of the problem of the dynamics of a dropped sphere in unbounded fluids — both homogeneous and two-layer fluids. In a perfectly symmetrical scenario, the sphere should descend in a straight line indefinitely. According to Bukreev, their experiments show that, in fact, the sphere does

not descend in a straight line, but instead after a certain period of time, it suddenly swerves to one side. The same effect is observed in the case of a two-layer fluid (kerosene/water). Further, experiments revealed that a drop of kerosene may be trapped by the hydrodynamic wake behind the falling sphere to a distance of 30 to 40 sphere diameters, indicating stability of the "sphere-kerosene drop" composite. Bukreev claimed that these results are of fundamental significance but have received inadequate attention in the past. The basis for Bukreev's assertion is explained as follows:

The problem of the falling sphere was first noted by Newton and later observed by other scientists, particularly in the early decades of the 20th century. The results were summarized by L. Schiller in 1932. The major observation was the striking difference in drag coefficients of a free-falling sphere and a fixed sphere under otherwise similar conditions. In particular, under certain conditions, the drag coefficient of a free-falling sphere is three times larger than that of a fixed sphere. And yet, monographs on hydrodynamics contain only the classic curve of drag coefficient versus Reynolds number obtained by C. Wieselsberger for a fixed sphere. Results for the free-falling sphere have received inadequate attention, although some systematic experiments have been conducted (e.g., H. Viets and D. Lee 1971 and I. Nakamura 1976).

For a fixed sphere, the drag coefficient depends only on the Reynolds number, albeit in a complex manner. For a free-falling sphere, the solution depends on two parameters: a "kind of Reynolds number," and the density difference between the fluid and the sphere. In the general case, the desired dependence can be represented as a surface in 3-dimensional space or as a set of plane curves. Based on experimental data already published, only several dozen points on the set of curves can be found. Prof. Bukreev has obtained several points from his own experimental investigations.

Existing theory is inadequate, as it encompasses only a narrow range of parameters that have already been studied (the classic Stokes solution and its generalizations by early 20th century investigators). Further advances beyond this parameter range can be made only by experimental means. The existing sparse data fall into the parameter range of either definite stability or obvious instability. Little is known about the nebulous boundary between the two regions. Hence, there is a definite need for experimental data in this area.

Within a month of our site visit, a proposal was submitted to the Office of Naval Research by LIH for a two-year research effort to further investigate the problem of a falling sphere in homogeneous and two-layer fluids.

Underwater Explosions Laboratory

Prof. Valery K. Kedrinskii, deputy director of LIH, discussed some of the work being done in underwater explosions. The investigations encompass a broad spectrum of processes, including: shock wave generation and propagation, cavitation, fluid fracture under

explosive loading, jet flows due to underwater explosions, and shock wave propagation in chemically active bubbly media.

As an illustration of the practical importance of the preceding research, Kedrinskii cited the phenomenon of accidental detonation in bubbly liquids, due to bubble cavitation. This was shown to be a possible explanation of large-scale fuel explosions in closed volumes under shock loading as a result of an accident during transportation. In particular, the energy absorbed by the cavitating bubbles from the incident shock wave is sufficient to raise their internal temperature to the ignition level, thereby causing the bubble explosion. Kedrinskii also discussed in some detail their efforts to develop various types of underwater acoustic charges. Over a period of about 20 years the institute has examined a variety of sound sources, including explosive cord line charges; a vertical line array of concentrated, single-frequency charges; ring charges; and spiral charges. The need for diverse source types derives from the different source characteristics (directivity, signal duration, and spectral content) required for various applications.

SUMMARY

The Lavrentyev Institute of Hydrodynamics is a prestigious scientific establishment and has done important fundamental research in mechanics, hydrodynamics, and detonation processes. They have seen some reduction in funding but have begun to successfully transition to international contracts to offset internal RAS funding losses. The area of explosion processes seems one of the most vibrant disciplines and also seems the most likely to provide processes and products for the civil sector.

The Laboratory of Applied Hydrodynamics has several decades of experience in diverse areas of hydrodynamics. Their contributions have ranged from development of innovative solutions to practical problems, to pioneering efforts in the fundamentals of hydrodynamics.

Some of the results in underwater explosions, cavitation, and submerged bodies have been published in English, but it would appear that they have been more productive than prolific.

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Date Visited: October 23, 1995

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Hosts:

Academician George B. Elyakov, Director, Vice President of RAS, Chairman FEB
Natalie M. Sheptova, Assistant Director for Foreign Relations

BACKGROUND

The Pacific Institute of Bioorganic Chemistry (PIBC) was founded as the "Institute of Biological Active Agents" in 1964. It was given its present name in 1975 and is part of the Far Eastern Branch of the Russian Academy of Sciences. Academician Elyakov has been its director for the past 30 years. He is also presently the chairman of the Far Eastern Branch of the Russian Academy of Sciences and a vice president of the academy.

The PIBC's activities are coordinated with those of similar institutes in Russia working on problems of physicochemical biology and biotechnology. In the Russian Far East there is a wealth of terrestrial and marine flora and fauna, some of it unique to this part of the world. While the institute works with both land and sea organisms, the primary research focus is on the study of marine organisms at the molecular level. This direction offers the greatest potential for discovery of bioactive substances that can be used for the benefit of man. Some examples of the benefits are given below:

- Foodstuffs
- Food supplements and additives
- Medicines
- Enhancement of agriculture (for both plants and animal husbandry)
- Biotechnology development for a variety of commercial uses

Products developed at PIBC have been awarded Russian patents; but due to the present severe economic conditions, the expensive process of obtaining foreign patent protection has not been attempted. Nevertheless, the work of this organization has attracted foreign interest from government organizations such as the U.S. National Institutes of Health (NIH) and major drug companies such as Glaxo and Hoffman LaRoche.

In addition to obtaining rights to both use and manufacture bioactive substances developed by the institute, foreign organizations are also very interested in the 8,000 strain reference collection developed here. The marine microorganisms collection alone contains 700 strains of bacteria, 500 of actinomycetes, and 500 marine fungi. The institute has offered all, or parts of this documented collection for use by other research institutions through purchase or leasing for fixed periods of time. No transfers have yet taken place.

The visibility of the organization was raised considerably a number of years ago when it was visited by then-Soviet Union Chairman Mikhail Gorbachev. During the visit he was briefed on heart medicines developed over a period of 10 years at PIBC. He was sufficiently impressed by this work that he personally ordered increased funding support for the biomedical research program.

At present, the institute, located in a research campus in the northern part of Vladivostok, has 350 workers, of whom 70 are Ph.D.s and 15 are doctors of science. Part of the support staff is associated with the maintenance and operation of the institute's dedicated research vessel, *Akademik Oparin*.

The institute's annual budget is about 2 billion rubles. The total budget for the Far Eastern branch of the Russian Academy of Sciences is 110 billion rubles. This is spread among 26 scientific institutions. Thus, PIBC gets about 1.8% of the total research support funds allocated to this region.

The WTEC team spent approximately two hours at this site. All of this time was spent in the director's conference room where he briefed us on the work of his organization. Some of the viewgraph transparencies he used are appended to this site report (Figs. 2.20 - 2.23, Table 2.4). No laboratories or other facilities in the institute building were visited.

Unfortunately, the PIBC did not have any publications in English available for the team. Therefore, this site report is largely built on the briefing provided by the director, a few viewgraph slides, and the author's slight acquaintance with the general field of marine bioactive substances.

The team also visited the oceanographic research ship *Akademik Oparin*. Details of this visit are the subject of a separate site report (p. 19).

RESEARCH AND DEVELOPMENT ACTIVITIES

As Academician Elyakov pointed out, land and ocean organisms' paths of evolution divided hundreds of millions of years ago. Therefore, while plant and animal extracts have been used for medicinal purposes for thousands of years, it is only recently that the search for new substances has extended to the sea. Because of the diverse evolutionary paths, there is every reason to expect major new advances from bioactive substances extracted from marine organisms.

The following breakdown of the publications list of the institute gives a good idea of the present focus of the marine bioactive substances research effort:

<u>Organism</u>	<u>Percentage of PIBC publications</u>
Seaweeds	35%
Sponges	20%
Echinoderms	18%
Coelenterates	12%
Fishes	10%
Microorganisms*	5%

* (includes: bacteria, actinomycetes and marine fungi)

One major research direction in seaweeds lies in the investigation of polysaccharides. It is believed they may have biomedical activities that may provide relief for AIDS patients. The institute's studies in the field of molecular immunology have enabled scientists to extract from various species of mollusks and seaweeds substances that stimulate the immune system and react against tumors without toxic effects.

Techniques have been found for extracting from inedible marine materials and fisheries waste (a previously wasted byproduct of commercial fishing) substances such as antioxidants, fungoid antibiotics, and immune system stimulants. The heart medicine that impressed Chairman Gorbachev was derived from an inedible marine animal, the sea urchin.

Investigations of marine invertebrate microorganisms capable of biosynthesis of substances with antimicrobial and cytotoxicogenic activities are being actively pursued. Strains of marine microorganisms have been found that produce a number of unique enzymes that appear to be very promising in the field of genetic engineering.

The PIBC research program does not eventually point towards commercial harvesting of natural flora and fauna as sources for bioactive substances. Rather, they collect and analyze the natural organisms for bioactive properties. If the properties found are unique or superior to known substances, then the next step is to learn how to synthesize the natural bioactive compounds. The well-understood sequence of events is as follows:

1. Isolation of the bioactive substance from the natural organism (plant or animal)
2. Purification of the substance to make it 'free-standing' for further analysis
3. Structural investigation of the substance's chemical makeup
4. Creation of a bioassay to determine all of the possible activities
5. Synthesis of the natural compound through creation of a man-made chemical compound.

The "Trends of Marine Biotechnology Development," according to Academician Elyakov, are shown in Figure 2.20. Here it can be seen how marine organisms and fish industry wastes contain the resource pool for bioactivity investigations. Further, the various applications and activities are indicated as they are derived from the natural substances. Some other viewgraphs presented by the hosts are also attached (Figs 2.21 - 2.23).

At present, the institute's ocean research activities do not include investigation of the chemosynthetic organisms associated with hydrothermal vent areas on the deep-sea floor.

PIBC scientists have worked on joint programs in bioactive substances with researchers from the Harbor Branch Oceanographic Institution at Fort Pierce, Florida. Scientists from each institution have shared research cruises on each other's vessels and have done work together at both laboratories on shore. There appears to be good cooperation and mutual respect between these two organizations.

COMMERCIAL ACTIVITIES

Academician Elyakov showed a series of three viewgraphs titled, "Medicinal Preparations Obtained at the Pacific Institute for Bioorganic Chemistry." These are reproduced as Table 2.4. The preparations of marine origin were as follows:

<u>Commercial name</u>	<u>Activity</u>
Zosterin	Decreases toxicity of antitumor drugs; purges heavy metals from human organisms
Preparation "CD"	Strong immuno-stimulator; increases level of antibodies
Histochrom	Cardioprotector and anti-inflammatory agent
Collagenase	Treatment of wounds; removal of dead and scar tissue
Translam	Antitumor and immunostimulation

All these drug products are covered by active Russian patents. All these patents are owned by PIBC, with the exception of Histochrom. This patent ownership is shared with the State Medical Institute in Vladivostok and the Cardiology Research Center of the Russian Academy of Medicinal Sciences (Moscow).

In addition to the marine-derived products, there are two others that are developed from terrestrial plants:

<u>Commercial Name</u>	<u>Activity</u>
Maxsar	Natural antioxidant.
Cetris	Bacteriostat, may be good for prophylaxis of cancer.

Both of these products are protected by Russian patents owned by the institute. More extensive details on these marine and terrestrial-origin compounds are in Table 2.4.

Perhaps two of the more unusual products from PIBC are liquid medicines which have rather high alcohol contents (80-90 proof). One is called "Russian Balm" and the other, a vodka- type product, "Golden Horn." Both are made from extracts of various plants which are said to have medicinal value. These are not distilled liquor products: the alcohol is used to extract the medicinal oils from the plant materials. While Russian Balm contains several plant extracts, Golden Horn is derived from a single plant "Eleutherococc" (Eleutherococcus Maxim). The WTEC team had the opportunity to sample both products.

PIBC operates its own manufacturing facility in the basement of the institute building. Most of the products described here are made on site in limited quantities.

SUMMARY

Director Elyakov said the institute's "dream" is to be set up as a company, independent of the government. In this way a rational, profit-making enterprise could be organized to market the discoveries, reference collections, and products produced by PIBC. At present, any monies made are taken by the government, and there is little incentive to develop more commercial products.

If PIBC could become an independent organization, Academician Elyakov believes it could be profitable within three years. This could be done through joint ventures, direct sales of products manufactured locally, licensing of production to other companies, and payment of royalties for processes and products developed by PIBC but produced elsewhere.

As noted earlier, the WTEC team did not visit any of the laboratory or production facilities at the institute. Also, no printed materials were received describing the PIBC and its work. Therefore, this site report is based primarily on Director Elyakov's briefing to the team and on subsequent discussions with members of the institute staff during the visit to the *Akademik Oparin* on October 27.

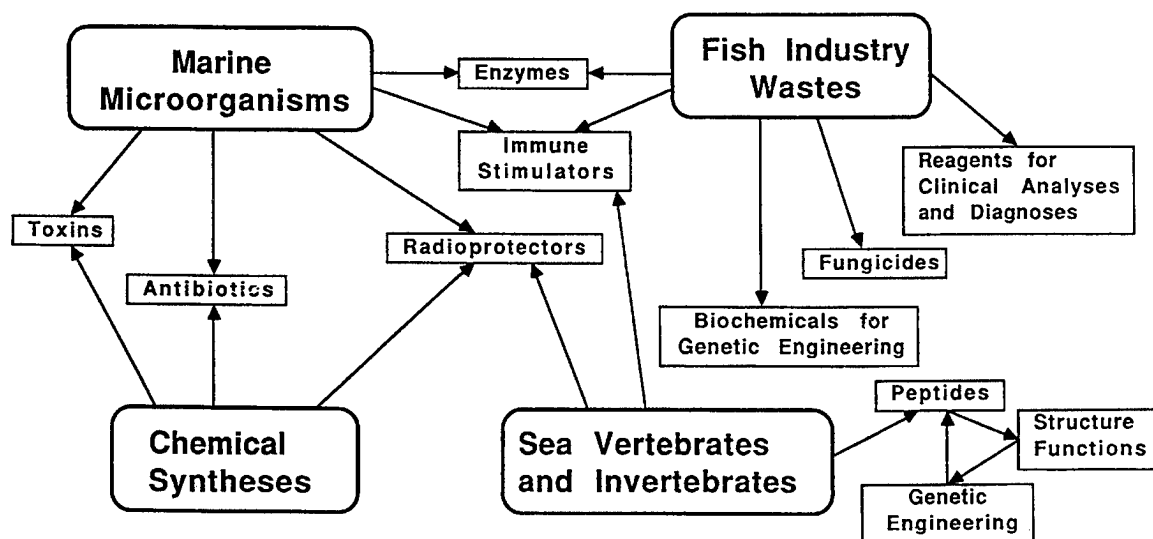
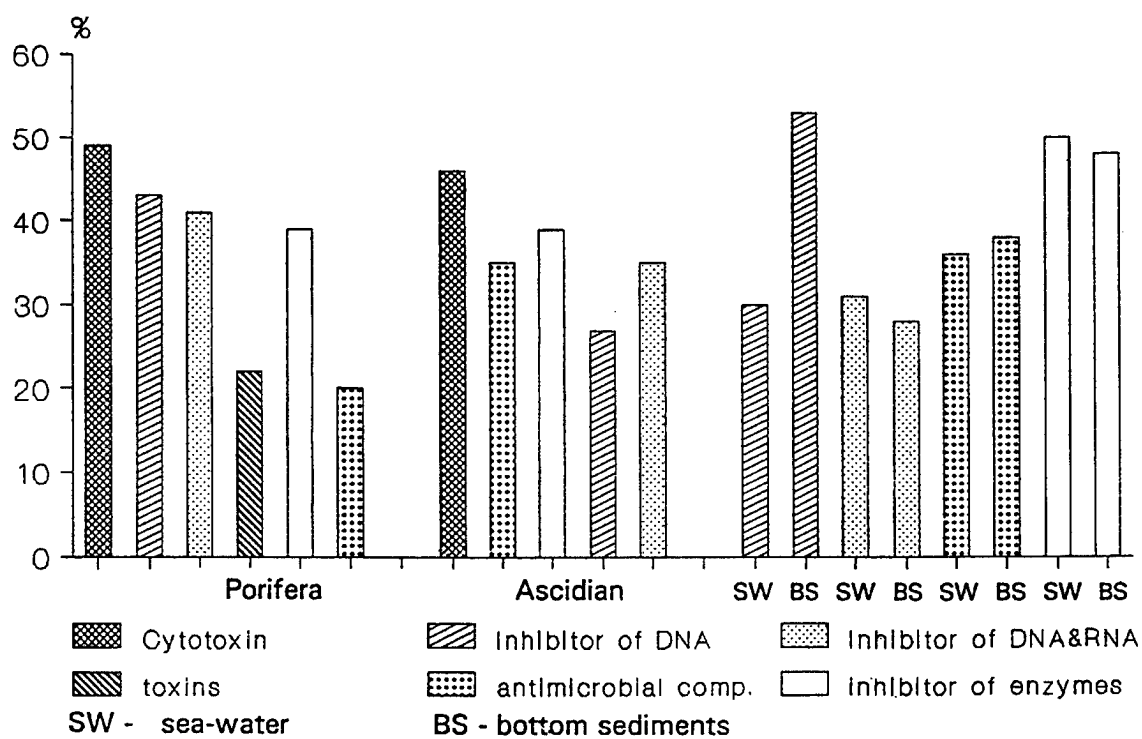


Fig. 2.20. Trends of marine biotechnology development.



North and North-East of Australia

Fig. 2.21. The distribution of microorganisms producing physiologically active compounds.

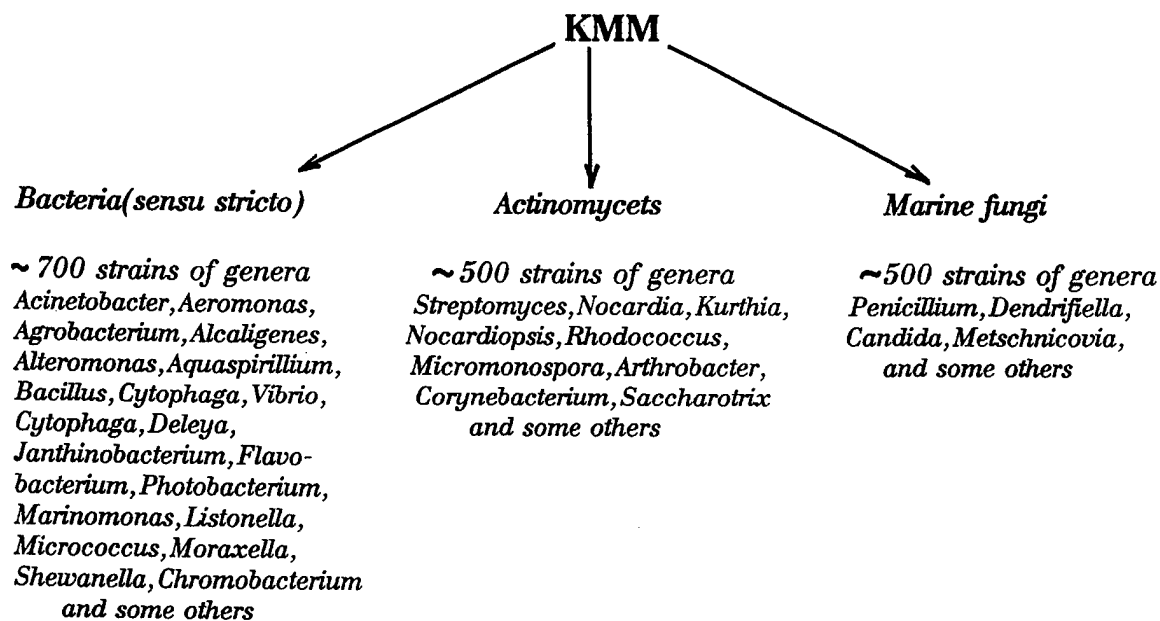


Fig. 2.22. Collection of marine microorganisms in Pacific Institution of Bioorganic Chemistry FEB RAS (Official acronym in World Federation for Culture Collection [WFCC]).

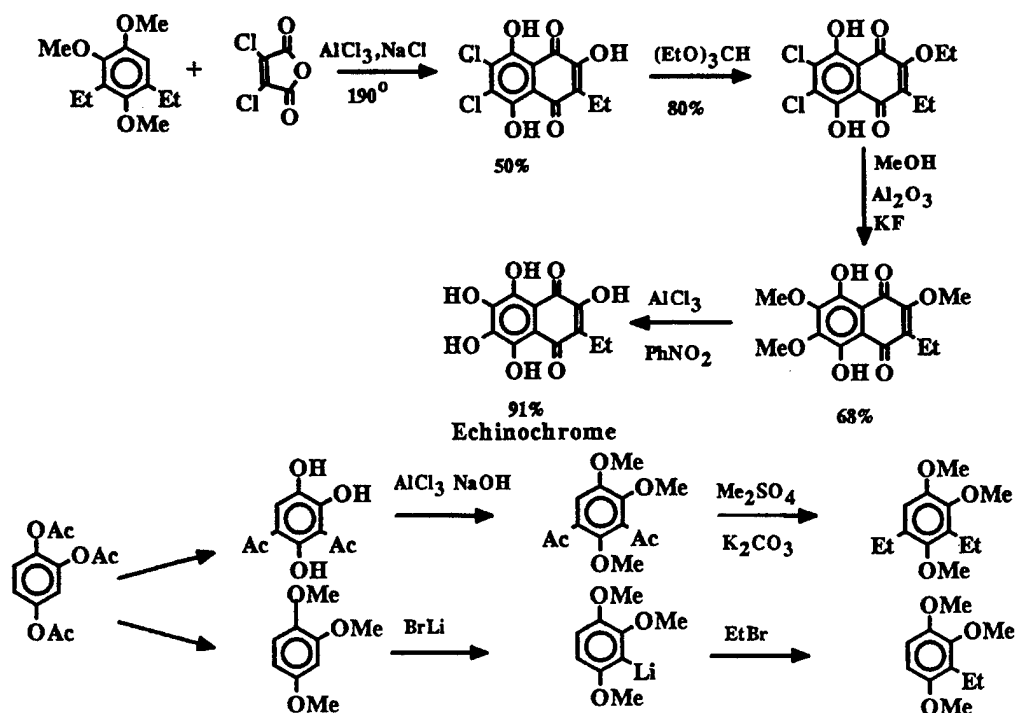


Fig. 2.23. Echinochrome synthesis.

Table 2.4
Medical Preparations Obtained

Name. Properties. Applications	Advanced Level	Rightful Defense	Realization of the Project
I. PREPARATION OF MARINE ORIGIN			
"ZOSTERIN" Pectin from sea-grasses. 1. Decreases toxicity of cytotoxic components of known antitumor drugs and increases their endurable doses. 2. Removes heavy metals from a human, organism (at radiation sickness, poisoning, etc.). 3. Treats stomach ulcer with low acidity.	Permitted in Russia as a medicinal and prophylactic supplement to food-stuffs.	Russian Patent Application No. 5037519 (positive resolution of 01.19.1993). Owner: PIBC	To arrange the production of ZOSTERIN from sea-grasses.
PREPARATION "CD" Low molecular weight compound. Strong immunostimulator. Increases activity of macrofags and level of antibodies.	Pharmacological studies are nearly completed. Under use in veterinary applications.	Russian Patent of Russia Application No. 4891144 (positive resolution of 01.03.92). Owner: PIBC	To complete the pharmacological studies.
"HISTOCHROM" Low molecular weight compound. Natural antioxidant. 1. Cardioprotector. Decreases the necrosis zone at affection of myocardial muscle infarction). 2. Anti-inflammatory remedy for ophthalmology. Treats acute inflammations of any nature (burns, haemophthalmus, etc.).	Permitted for the first stage of the clinical trials in ophthalmology and the second stage of the clinical trials in cardiology. Tried by volunteers.	1. Russian Patent No. 1508535 of 07.01.91 Owner: PIBC 2. Russian Patent No. 1826909 of 08.01.90 Owners: PIBC and State Medical Institute (Vladivostok) 3. Russian Patent No. 1833544 Owners: PIBC and Cardiology Research Centre of the Russian Academy of Medicinal Sciences (CRC, Moscow).	To develop technology for the total chemical synthesis.
"COLLAGENASE" A complex of proteolytic enzymes. 1. Treats suppurative, necrotic wounds. 2. Resolves scars and removes necrotic skin after cosmetic operations; smoothes out wrinkles. 3. Is used for producing food hydrolyzates of animal, plant and microbial proteins for medicinal diets.	1. Permitted for the first stage of clinical trials. 2. Collagenic peptides as components for cosmetic creams, shampoo and lotions were obtained.	Russian Patent.	To arrange the industrial production from marine raw materials.
"TRANSLAM" Immunomodulator of polysaccharide origin. Structure and biological activity is close to the well-known antitumor and immunostimulatory preparations Lentinan and Schizophyllan.	In the process of preclinical trials as a radioprotector.	Two applications for Russian Patents: No. 93019991 of 04.19.93; No. 93019966 of 08.06.93. Owner: PIBC	To develop enzymatic technology for the production.

II. PREPARATIONS FROM TERRESTRIAL PLANTS.			
<p>"MAXSAR"</p> <p>Natural antioxidant. Inhibits free radicals and depresses toxic products of lypoper-oxidation.</p> <p>1. Treats thromboses, atheroscleroses and various toxic affections of liver.</p>	<p>Pharmacological trials have been completed. Tried by volunteers.</p>	<p>Russian Patent No.1519147 of 03.23.93</p> <p>Owner: PIBC</p>	<p>To arrange the industrial production from Far-Eastern plant.</p>
<p>"CETRIS"</p> <p>Preparation from lichen. Demonstrates bacteriostatic and stimulatory activities.</p> <p>1. Was first to use successfully for treating mastitis.</p> <p>2. May be promising for prophylaxis of cancer diseases.</p>	<p>Tested for specific, common and acute toxicities (State Medical Institute, Tomsk).</p> <p>Tried by volunteers.</p>	<p>Russian Patent Application No. 5056927 (the positive resolution of 04.28.93). Owner: PIBC</p>	<p>To arrange the industrial production from raw plant material.</p>

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E. F. Orlov

Renat D. Medzhitov, Head, Sea Technology Research Division

Vladimir A. Shchurov, Head, Lab. of Ocean Noise

Dr. Shulskov

Lev F. Bondar, Chief, Laboratory of Acoustic Sounding of Ocean

BACKGROUND

The Pacific Oceanological Institute (POI) is the major institution in FEB RAS. It was founded in 1973; it presently has a staff of over 600 people, including approximately 270 scientists, of whom 160 are professors and doctors of science. As part of their multidisciplinary marine program, the researchers of the institute carry out experiments in various geographic areas: the Pacific Ocean, the Sea of Okhotsk, the Bering Sea, the Sea of Japan, the East China Sea, the Philippine Sea, the South China Sea, etc. An offshore experimental station on Popov Island near Vladivostok provides facilities for operations in the littoral zone.

RESEARCH AND DEVELOPMENT ACTIVITIES

POI focuses on the following research areas:

- Experimental and theoretical oceanology, including investigations of ocean processes and dynamics, their spatial and temporal scales of variability, and mathematical modeling of these processes

- Underwater acoustics, including the use of underwater acoustics to investigate the ocean, the effects of the ocean environment on acoustics, and applied underwater acoustics
- Ocean-atmosphere interaction, using experiments and numerical simulation
- Assessment of the status of water ecosystems, including the effect of man, using developed bio-geochemical methods
- Geological / geophysical investigations of the sea bottom, with emphasis on its origin and development and on its potential for supplying mineral resources.

INDIVIDUAL REPORTS

Multidimensional Signal Analysis

Professor Gennady Y. Voloshin, deputy director of POI, provided a brief overview of the work the institute. He emphasized the work done in the area of multidimensional signal analysis. In particular, he stated that they perform correlation and spectral analysis using a method which is superior to the FFT methods — viz., their method is faster than FFT methods and, in addition, gives *exact* correspondence between the spectral density and correlation even for discrete series (unlike the FFT).

Low Frequency Acoustics

Dr. E. F. Orlov discussed low-frequency acoustics (one to "hundreds" of Hz). He emphasized the use of "acoustic interferometry" to investigate the spatial coherence structure of low-frequency acoustic fields in the ocean. Broadband acoustic energy propagating in an ocean waveguide may exhibit a two-dimensional space-frequency spectrum determined by the modal interference of the waveguide modes. Since the modal interference pattern is sensitive to relatively small fluctuations in the oceanographic parameters (index of refraction), changes in the pattern may be used to infer the properties of the medium along the path of propagation. Dr. Orlov suggested that the use of interference phase tomography is a promising way to study the characteristics of the sea bottom in shallow water, on the continental slope, and in deep-sea areas.

Electric and Magnetic Fields in Ocean Currents and Waves

Dr. Renat D. Medzhitov, head of the Sea Technology Research Division, discussed the use of electric and magnetic fields to study ocean properties. In particular, he is interested in electromagnetic fields induced by oceanic currents and by surface and internal waves. The investigation is not confined to theoretical work but includes development of instrumentation for this purpose (e.g., towed electromagnetic sensors). Among the examples and possible applications, he mentioned the use of virtual current distributions obtained from separated electrodes to determine the water distribution in the Bering Sea.

Micro- and Mesoscale Processes

Dr. Shulskov reviewed their efforts in monitoring micro- and mesoscale processes in the northern Pacific. These processes, often referred to as the ocean "weather," play a significant role in the transfer of ocean properties and substances. They affect not only biological activity and the distribution of marine organisms but also pertinent oceanographic parameters, such as the propagation of sound. Consequently, acoustic sounding is an effective means to remotely sense micro- and mesoscale processes and in many ways is preferable to conventional monitoring methods — including drifting ships, satellites, stationary and floating buoys, etc. The acoustic method is characterized by high spatial resolution, increased information content, and continuous measurements while underway. The scattering of acoustic energy by gas bubbles, microorganisms, and other microscale hydrophysical nonuniformities can be used to observe frontal zones, eddies, jet streams, intrusion, the processes of vertical mixing in the upper ocean layers, etc.

Shulskov presented some of the results of their measurements from the research vessel *Academik M. A. Lavrentyev* using a multifrequency (broadband) acoustic source along with towed temperature and salinity sensors. He proposed the use of well-equipped fishing vessels to perform large scale systematic measurements in the northwest section of the Pacific Ocean and its marginal seas. This, he suggested, would result in observations of quality and quantity sufficient not only to provide a detailed picture of mesoscale physical and biological processes but also to predict them.

Scalar-Vector Analysis of Ambient Noise in Water

Dr. Vladimir A. Shchurov discussed investigations of ambient noise in deep and shallow water using the "scalar-vector" method. The method is based on the simultaneous measurement at a given point of the acoustic pressure field and three orthogonal components of the particle velocity of the medium. Combined processing of the four acoustical field components enables the computation of the energy flux density vector (Poynting Vector) and hence of the flow of ambient noise energy. The investigation of the motion of ambient noise energy has led to several important applications, including those discussed below.

- A means of categorizing the ambient noise field into isotropic (incoherent) and anisotropic (coherent) components. The relative contributions of isotropic (diffuse) and anisotropic noise depend upon frequency, the sea surface wind speed, properties of the vertical and horizontal noise power flows, and the statistics of the acoustic pressure and particle velocity fields. This allows one to deduce relevant information on the behavior of realistic noise fields. For example, Prof. Shchurov and his colleagues have demonstrated that the anisotropic noise field is represented by a superposition of two uncorrelated fields: a horizontal power flow and a vertical power flow. The vertical power flow of dynamic noises transports energy from the noisy ocean surface to bottom depths of the ocean waveguide. The horizontal flow transfers energy "forward," in the

direction of surface wave propagation (wind-induced roughness) (200-1000 Hz frequency band). This appears to be a fundamental result, not only offering insight into ambient noise propagation but also suggesting an acoustic means of monitoring ocean surface roughness.

- Knowledge of the ambient noise flow can be used for noise cancellation or suppression. For example, ambient noise can be suppressed by the "opposing" field of a local acoustic signal. This has the effect of enhancing the signal-to-noise ratio, thereby greatly assisting the task of target detection in a noisy background. This technique can also be applied to suppression of reverberation in an active detection scenario. This is based on the fact that a large part of reverberant energy is isotropic.

Experimental systems based on the preceding concepts have been developed and used in both deep-water areas and coastal zones. These have included both bottom-moored and drifting buoy systems, operating over a frequency range from 1 to 1000 Hz, and at depths between 10 and 2000 meters. The Shchurov group has published its results in several English-language publications and is interested in joint work with other countries.

Analysis of the Variability of Underwater Acoustic Signals

Dr. Lev F. Bondar discussed his work on the variability of underwater acoustic signals. The nonhomogeneities of the sea, coupled with the dynamic properties of shallow water, create a complex acoustic environment in coastal areas. In straits, for example, they have measured daily variations in ambient noise ranging from 10 to 20 dB. As a result, they do not rely exclusively on acoustic monitoring methods but simultaneously measure hydrophysical parameters. They use a special monitoring station in the shelf zone, within 100 km of Vladivostok, equipped with hydrophones, geophones, and a vertical array of additional sensors to monitor such things as internal waves.

SUMMARY

The Pacific Oceanological Institute (POI) is the major institution in FEB RAS. It probably ranks first among research institutions in the former Soviet Union in the area of acoustics of the ocean, although its activities cover a much broader spectrum of ocean exploration disciplines. Results of their investigations, particularly in ambient noise, have been published in a number of places. However, it is not clear whether the significance of this work has been understood by U.S. and other researchers in the field.

The POI participates in various international projects devoted to ocean studies, including WOCE, WESTPAC, JGOFS, and others. They are eager for joint projects and patents, particularly with the United States.

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Site: **Russian Academy of Sciences
Far Eastern Branch
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Vladivostok, 690600, Russia
Phone: (4232) 222528, 223721
Fax: (4232) 228750**

Date Visited: October 23, 1995

WTEC Attendees:

J. B. Mooney, Jr. (report author), H. B. Ali, R. Blidberg, S. Chechin, M. J. DeHaemer, L. Gentry, J. Moniz, D. Walsh

Host:

Academician George B. Elyakov, Vice-President RAS, Chairman of the Far Eastern Branch. Email: olyakow@piboc.marine.su

BACKGROUND

The Russian Academy of Sciences (RAS) is divided into three branches: The Urals Branch with headquarters in Yekaterinberg, the Siberian Branch in Novosibirsk and Far Eastern Branch in Vladivostok. This site visit report involves the Far Eastern Branch (FEB). The FEB was founded a quarter century ago. This branch has six regional centers. The Vladivostok regional center has 14 institutes, the Kharbarovsk regional center 7, Sakalin 3, Blagoveshchensk 2, Magadan 4, and Kamchatka 5. FEB RAS has 2 native preserves and 1 special marine preserve. The Magadan Territorial Center for Arctic Studies has a cooperative program on arctic issues with the University of Alaska – Fairbanks for earthquakes and seismic activity. The Japanese are involved in this cooperative effort.

The total staff of the FEB has dropped from 12,789 in 1989 to 8,178 in 1994. During this same period the research staff has dropped from 3,011 to 2,442. The number of doctors of science in the FEB has increased steadily from 143 in 1989 to 213 in 1994. The number of candidates of science has decreased from 1,385 in 1989 to 1,172 in 1994. Doctors of science are equivalent to professors in the United States and candidates of science are equivalent to assistant professors. The population of academicians in the FEB has grown from 8 in 1989 to 10 in 1994. Academicians are full-fledged members of the Russian Academy of Sciences. The number of corresponding members of the RAS (first level members) remains at 16, the same number as in 1989. In 1991 the number peaked at 25.



Fig. 2.24. Scientific centers and stations of FEB RAS.

The largest research fleet of the RAS is registered in the FEB in Vladivostok. There are 15 ships in the fleet (Table 2.5). Table 2.6 includes additional information on the capabilities of the largest of these.

The FEB institutes located in Vladivostok include the Presidium FEB RAS; the Institute of Applied Mathematics; the Institute of Sea Technology Problems; the Institute of Automation and Control Processes with the Computer Center; the Institute of Chemistry; the Pacific Institute of Bioorganic Chemistry; the Institute of Biology and Pedology; the Institute of Marine Biology; the Far Eastern Institute of Geology; the Pacific Oceanological Institute; the Pacific Institute of Geography; the Institute of Economical and International Ocean Development Studies; the Institute of History, Archaeology, and Ethnography of Far Eastern Nations; and the Botanical Garden.

The major research directions of the FEB institutes are earth sciences 44.5%, biology and biotechnology 27.9%, physics and technical sciences 16.5%, chemistry 5.8%, and social sciences 5.2%.

FEB funding in 1995 was 110 billion rubles (\$24.3 million). This is about half the funding before Perestroika. The various institutes in the FEB are seeking funds in addition to government funds. There has been some success in this regard from foreign entities and from some Russian industries.

This site visit was a courtesy call on our host Academician George B. Elyakov, vice-president of the Russian Academy of Sciences and chairman of the Far Eastern Branch. After this site visit our group visited various institutes of the Far Eastern Branch during the five-day period.

Table 2.5
Research Fleet of FEB RAS

Ship's Name	Construction [year country]	Displacement (tons)	Crew	Scientists	Region of Voyage
1. <i>Akademik A. Nesmeyanov</i>	1982 Poland	6280	62	65	unlimited
2. <i>Akademic A. Vinogradov</i>	1983 Poland	6280	64	65	unlimited
3. <i>Akademic M. Lavrentiev</i>	1984 Finland	2600	43	25	unlimited
4. <i>Akademic Oparin</i>	1985 Finland	2600	46	25	unlimited
5. <i>Professor Bogorov</i>	1976 Finland	1657	34	26	unlimited
6. <i>Morskoy Geophysik</i>	1975 USSR	1124	28	12	unlimited
7. <i>Vulkanolog</i>	1976 USSR	1125	28	12	unlimited
8. <i>Professor Gagarinsky</i>	1987 USSR	1185	29	11	unlimited
9. <i>Gidronavt</i>	1975 USSR	300	18	7	50 miles
10. <i>Borey</i>	1976 USSR	266	16	4	200 miles
11. <i>Brig</i>	1977 USSR	266	16	4	200 miles
12. <i>Berill</i>	1978 USSR	266	16	4	200 miles
13. <i>Ametist</i>	1979 USSR	266	16	4	200 miles
14. <i>Basalt</i>	1984 USSR	266	16	4	200 miles
15. <i>Lugovoe</i>	1986 USSR	266	17	4	200 miles

Table 2.6
Specialization and Main Equipment of Larger FEB RAS Vessels

Names of the Research Vessels	Specialization, Main equipment
<i>Akad. Nesmeyanov</i>	Wide range of oceanographic research (biology, hydrophysics, geophysics, geology). EC-1010. Special winches and cranebeams. Echosounding devices GEL-3 & EL AC-E. Autoclaves, centrifuges. GBK250. Distillers, vacuum pumps, driers.
<i>Akad. Vinogradov</i>	Wide range of oceanographic research (Acousticoceanographics, hydrophysics, geophysics). EC-1010. Special winches & cranebeams. Echosounding devices GEL-3 & EL AC-E. Generators.
<i>Akad. Lavrentyev</i>	Complex geophysics, geochemical research
<i>Akad. Oparin</i>	Marine Biochemistry & Biotechnology 14 Labs, all equipment for collection & investigation of marine biologically active substances
<i>Prof. Bogorov</i>	Marine geology, & geophysics
<i>Prof. Gagarinsky</i>	Geophysics
<i>Vulkanolog</i>	Underwater volcanology
<i>Morskoy Geofizik</i>	Marine geology, geophysics

Site: **Russian Academy of Sciences
Siberian Branch
17 Lavrentyev Ave.
Novosibirsk, 630090, Russia**

Date of Visit: November 1, 1995

WTEC Attendees:

J. B. Mooney (report author), H. B. Ali, R. Blidberg, S. Chechin, M. J. DeHaemer, L. Gentry, J. Moniz

Host:

Academician Yuri Shokin, General Science Secretary, Presidium SB RAS
Phone: (3832) 353345 (353647 FAX). Email: shokin@hq.soan.nsk.su

BACKGROUND

The Russian Academy of Sciences (RAS) is divided into three branches. The Urals Branch headquartered in Yekaterinburg, the Far Eastern Branch in Vladivostok, and between the two the Siberian Branch (SB) is headquartered in the academic township (Akademgorodok) of Novosibirsk, which is about 30 kilometers outside the city of Novosibirsk. The city of Novosibirsk is located at the geographic center of Russia. The Siberian Branch RAS clearly covers a much larger geographic area of Russia than the other two branches. The SB RAS was founded in 1957. This branch of the RAS has 12 regional centers, in Novosibirsk, Irkutsk, Tomsk, Krasnoyarsk, Ulan-Ude, Omsk, Kemerovo, Tyumen, Barnaul, Chita, and Kyzyl. The SB is composed of over 74 research institutes and experimental design offices covering the fields of physics, mathematics, technical, chemical, biological, geological, and social sciences.

The branch employs 40,400 people. Five years ago the number was 55,000. Of these, 72% are employees in the 74 research institutes and 28% are in 13 support organizations. Among the 9,000 research staff of the SB there are about 55 academicians and 64 corresponding members of the RAS, 700 doctors of science, and 5000 candidates of sciences. Doctors of science are equivalent to professors in the United States and candidates of science are equivalent to assistant professors. Of the members of the SB RAS, 15% percent are younger than 33, and 30% are over 50 years of age. The distribution of personnel among the 12 divisions of the SB RAS is shown in Table 2.7.

Table 2.7
Distribution of Personnel Among Divisions

Novosibirsk	61.3%	OMSK	1.3%
Irkutsk	11.9%	Kemerovo	.7%
Tomsk	7.3%	Tyumen	.5%
Yakutsk	.6%	Barnaul	2.1%
Krasnoyarsk	5.9%	Chita	.4%
Ulan-Ude	2.4%	Kyzyl	.3%

The SB is experiencing decreasing budgets as indicated in percentages in Table 2.8. All 1990 figures are 100%. This site visit was a courtesy call on our host Academician Yuri Shokin, general science secretary of the SB RAS. Academician Shokin regards the branch as a large research corporation. As such they want to work directly with large companies and other established organizations, no middle men. Organizations deserving to work with the SB must work through official channels of the SB and its institutes. According to Shokin, this guarantees that researchers will be paid with minimal overhead charges. Academician Shokin indicated that the Novosibirsk Akademgorodok has the best institutes in Russia, as rated by foreigners.

Table 2.8
State Budget Percentages

Year	1990	1992	1993	1994
Science	100	41.8	27.8	18.5
Investments	100	23.2	22.0	16.7
Infrastructure Investments	100	76.6	53.8	48.0
Total Funding	100	40.0	28.9	21.2

Site: **Varyag**
Varyag Plant
Russkaya Street 94
Vladivostok, 690105, Russia
Phone: (4232) 327824
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Date Visited: October 26, 1995

WTEC Attendees:

D. Walsh (report author), H. B. Ali, R. Blidberg, S. Chechin, M. J. DeHaemer, L. Gentry, J. Moniz, J. B. Mooney

Hosts:

Evgeniy N. Leonov, Director
Yuriy A. Filchenok, Vice President for Foreign Trade & Relations
Iosif N. Kanevsky, Director, Joint Stock Company, Dalpribor

(WTEC team visit to the Dalpribor site scheduled for this day was canceled, but Kanevsky briefed them on his company during the visit to Varyag. His comments are written up as the Dalpribor site report, p. 34).

BACKGROUND

Varyag was formed over 15 years ago to manufacture both military and commercial equipment. During the Soviet Union era, this facility was a state-owned factory producing equipment primarily for the navy and merchant marine. The types of products produced were: electrical and electronic equipment, robots, machines, and plastics. The majority of their business supported the Soviet shipbuilding industry, 90% for the navy and 10% for the merchant marine.

Procurement of equipment for naval and merchant vessels was usually in small production runs. Therefore, the present organization and layout of Varyag is more like a "job shop" than a manufacturing company. Understandably, this results in higher manufacturing overhead than for a company set up to mass-produce products.

Most of their military business orders, along with most of their government work, were lost in 1992-93. The volume of this work was reduced by 500% during this period of just two years. At this time, Varyag was privatized and become a "joint stock company" with shares held by both private investors and the government. Now, the primary business of the company is the manufacture of consumer goods and medical equipment. However,

Director Leonov stated that in terms of sales revenue, civil orders have not matched the former revenues from government business. He estimated that they have lost 50% of their business. There have been big problems in making the conversion from defense to the civil sector.

Since the organization of Varyag as a joint stock company, the management has had contacts with various foreign companies and businesses. Some overseas sales have been made, but this business has been limited by Varyag's increasing costs of operations and high taxation of its products. This taxation is a major, if not the primary, factor in limiting the company's viability. The taxes are a series of national and local government taxes which, added together, can add up to 90% of the value of the products produced.

In this high tax situation, Varyag cannot be competitive in international markets. Similar products made on West Coast of the United States and in Japan are actually cheaper, even though Varyag's overhead, facilities, and labor costs are only a fraction what they are in those countries.

An additional difficulty was the loss of component supplier companies when the Soviet Union dissolved. Many of the companies in the former USSR that were suppliers to Varyag are no longer in Russia. Development of reliable, alternative sources of components has been difficult. The situation has been made even more difficult by their isolation from European Russia.

Finally, the close proximity of Japan has permitted low-cost, high quality products from that country to enter the Russian Far East. Many of these products (e.g., telephones, radios, etc.) compete directly with products manufactured by Varyag.

The WTEC team spent about two and a half hours at Varyag. Most of this time was occupied with the briefing presented by Director Leonov and Vice President Filchenok. At the end of the briefing there was a brief (30 minute) walk-through of one of the production areas. The quality of the work products seen was excellent, and both machined and electronic items were shown to team members. The shop area was clean, and the production machines appeared to be well-maintained. The production machines were numerically controlled but were older types.

The buildings occupied by Varyag were quite extensive. Photographs in the "Varyag Factory" brochure show multistory structures. However, the team was told that only two or three of the shops were presently working due to electric power shortages in the Vladivostok area. Director Leonov did say that these shops were working three shifts.

There are 1,700 people presently employed at this site; prior to Perestroika, in 1989, there were 3,700 employees. A high percentage are engineers.

RESEARCH AND DEVELOPMENT ACTIVITIES

Varyag does neither research and development nor prototype development at present. The engineering staff is primarily concerned with production engineering rather than design and engineering of new products. In the future they would like to develop a design staff to do full product design, prototyping, and development in-house. In this way Varyag could eventually become a vertically integrated manufacturing company for limited-volume production runs.

COMMERCIAL ACTIVITIES

Varyag currently offers the following products:

- Telephones of several different models and types
- Medical machines
- Plastic goods in various forms, such as children's toys and household goods
- Heavy metal goods for security installations (e.g., bank doors, safes, etc.)
- Electro-hydraulic equipment
- Small "Mini-bowling Alley" game machines
- Portable "Stereo Radio Double Cassette Recorders"
- Some fabric materials such as tote bags

Not all of these lines are in production at present, and those that are being produced are in small quantities. However, the company can quickly adjust production quantities. What they cannot do very well is to mass-produce large quantities. A considerable investment in new production equipment would be required to do this. At present, this is not affordable for Varyag.

Director Leonov indicated that the company still gets a small number of military orders as well as orders from the shipbuilding industry for merchant ship equipment.

The company hopes to get new contracts from a joint Canadian-Russian nuclear power plant development to be built in the Vladivostok region. The project is not yet fully approved. Varyag's "perfect world scenario" would be to supply their shipboard products to a major shipyard which would be built in the Vladivostok area. At present, there are seven repair yards and one small shipyard (fishing boats, ferries, etc.) but no large, newly built yard.

SUMMARY

Varyag has a trained work force and relatively good production facilities. Location in the largest seaport in the Russian Far East, good railroad service connections through to European Russia (and beyond), and an international airport nearby provide the necessary facilities for importing raw materials and components as well as shipment of finished goods. Labor costs are very low for the skills and type of products available. However, high taxation by all levels of government has created a situation where at present this company cannot be very competitive in the international marketplace. In addition, the company needs to reconsider its product lines to avoid direct competition with better-known and lower-cost (at present) Japanese products.

Vice President Filchenok told the team that one of his responsibilities was foreign business development. In estimating his company's costs to produce any given item, he said that if the government tax burden was substantially relieved, then Varyag could be a very low cost producer of high quality goods.

REFERENCE

Varyag Factory. Undated brochure.

APPENDICES

APPENDIX A. PROFESSIONAL EXPERIENCE OF PANELISTS AND OTHER TEAM MEMBERS

PANEL MEMBERS

John B. "Brad" Mooney Jr. (Panel Chair)

Affiliation: U.S. Navy, retired

Address: 2111 Jeff Davis Hwy., #1009 S, Alexandria, VA 22202

John B. "Brad" Mooney Jr., a retired admiral in the U.S. Navy, is an independent consultant to ocean engineering and research managers.

Admiral Mooney is a member of the board of directors of Coltec Industries, a member of the Marine Board of the U.S. National Research Council, and a member of the board of directors of the National Association of Marine Laboratories. He serves on the Naval Studies and Ocean Studies panels of the U.S. National Academy of Sciences. He is a former president of the U.S. Marine Technology Society and is the former president and managing director of Harbor Branch Oceanographic Institution, Inc. of Fort Pierce, Florida. Admiral Mooney retired from the U.S. Navy in 1987. His 34 years of commissioned military service included numerous assignments involving ocean engineering and research and development. He served on several submarines and commanded one. He is a former officer in charge of the bathyscaph *Trieste II*. He piloted *Trieste II* when it located the submarine *Thresher*. He was chief of U.S. Naval Research and served as oceanographer of the U.S. Navy, directing the Navy's Oceanography, Meteorology, and Hydrographic Survey Organization. In addition, he has served in an advisory capacity for oceanographic technology issues to both the White House and the U.S. Congress.

Admiral Mooney is a graduate of the U.S. Naval Academy. He is a member of the U.S. National Academy of Engineering and the U.S. National Engineering Honor Society.

Hassan B. Ali

Affiliation: ONR/Asian Office

Address: Akasaka Press Center, 7-23-17 Roppongi, Minato-ku, Tokyo 106, Japan

Hassan B. Ali was born in London, England, in 1943. He received the B.S. degree in physics from the City College of the City University of New York, New York, in 1966; the M.S. degree in physics from the American University, Washington, D.C., in 1971; and completed most of the formal requirements for the Ph.D. degree in acoustics from the Catholic University of America, Washington, D.C., 1977. He is presently enrolled in the Ph.D. program at the University of New Orleans.

He began work at the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) in 1966 where, from 1966 to 1980, he was engaged in research in structural vibration, acoustic radiation, and acoustic scattering (target strength). From 1980 to 1982 he worked at Booz, Allen and Hamilton, Inc., in Bethesda, Maryland, in the area of strategic and tactical communications (primarily acoustical). In 1982 he joined the SACLANT Undersea Research Centre in La Spezia, Italy, where for almost four years he worked in the areas of environmentally induced acoustic transmission fluctuations and seismo-acoustic propagation. Since 1986 he has worked at the Naval Research Laboratory, Stennis Space Center (NRL), in the areas of very low frequency (VLF) seismo-acoustic propagation and oceanographic variability. He was recently selected to be the next associate director for Ocean Science and Engineering, Office of Naval Research (ONR), Asia (Tokyo), effective July 1996.

He has written in the fields of structural vibration, underwater acoustic radiation, communications (acoustic and electromagnetic), seismo-acoustic propagation, transmission loss fluctuations, oceanographic variability, etc. Mr. Ali is a member of the Acoustical Society of America and the Institute of Electrical and Electronics Engineers.

D. Richard Blidberg

Affiliation: Northeastern University, Marine Science Center

Address: Marine Systems Engineering Laboratory, East Point Nahant, MA 01908

D. Richard Blidberg is the director of the Marine Systems Engineering Laboratory at Northeastern University's Marine Science Center in East Point Nahant, Massachusetts.

Mr. Blidberg has been involved in the development of autonomous underwater vehicle systems for over 20 years. He began his career in industry, where he was involved in the development of underwater acoustic systems and their applications in the polar regions. He subsequently assisted in the founding of the Marine Systems Engineering Laboratory of the

University of New Hampshire. In that laboratory's new home at Northeastern University, Mr. Blidberg continues to focus on the development of intelligent systems technology for undersea applications, particularly architectures for intelligent control. He has been responsible for the current Experimental Autonomous VEHICLE (EAVE) System Architecture Program since 1976. Mr. Blidberg has served on a number of committees focused on undersea systems technology, and has organized a series of international symposia on Unmanned Untethered Submersible Technology. Mr. Blidberg has published over 40 papers and technical reports and has consulted for a number of companies on AUV technology development.

Mr. Blidberg is a graduate of the University of New Hampshire, where he received his B.S. degree in electrical engineering. He has served on the board of directors for the Association for Unmanned Vehicle Systems and has been involved in many activities of the IEEE Oceanic Engineering Society and the Marine Technical Society.

Larry L. Gentry

Affiliation: Consultant, Lockheed Missiles & Space Co., Inc.

Address: P.O. Box 3504, Sunnyvale, CA 94089-3504

Larry L. Gentry has recently retired from a position as program manager for underwater vehicles in the Marine Systems Group at Lockheed Missiles and Space Co., Inc., in Sunnyvale, California.

Mr. Gentry has 30 years experience in the subsea and marine industry. From 1983 to the present, he has managed a number of underwater vehicle (UV) development programs. He has been responsible for fabrication and testing of UVs and for planning and supervising research and development projects for advanced technologies, including autonomous command and control, acoustic and optic communications, advanced structural materials, and precision inertial navigation. Formerly, he was involved in the development and installation of subsea oil and gas production systems and was one of the inventors of Lockheed's one-atmosphere subsea completion and production system. He has designed and operated both manned and unmanned undersea systems. Mr. Gentry holds nine patents or patents pending for marine systems and equipment.

Mr. Gentry has a B.S. degree in electrical engineering from Oregon State University and an M.S. degree in electrical engineering from San Jose State University. He is a past member of the Marine Board of the U.S. National Research Council and has served on submersible and diving consulting panels for the American Bureau of Shipping and Det Norske Veritas.

John C. Moniz

Affiliation: ONR/Office of Naval Research

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John C. Moniz is assigned to the Naval Surface Warfare Center Division, Indian Head, Maryland as head of the Propellant Formulation Branch, Research and Technology Department. His technical expertise lies in the areas of gun and solid rocket propellant formulation, gun system technology, gun propellant processing, and propulsion system development. His program management experience includes serving as propulsion system manager for the Deadeye five-inch gun-launched, rocket-assisted, semi-active, laser-guided projectile.

Mr. Moniz has recently served as a special assistant (detail assignment) with the Science Opportunities Program at the Office of Naval Research in Arlington, Virginia. In that capacity, he was involved in planning and executing the Science Opportunities Program, which was ONR's former Soviet Union science and technology cooperation program (now under the management of ONR/Europe under the new title, "Naval International Cooperative Opportunities in Science and Technology Program"). Since its inception in late 1993, the Science Opportunities Program has co-funded approximately 50 efforts at 35 Institutes of the former Soviet Union.

He had an earlier detail assignment at the Naval Sea Systems Command in the Insensitive Munitions Program Office.

Mr. Moniz received his B.S. in chemical engineering from the University of Maryland, College Park.

Don Walsh

Affiliation: International Maritime Inc.

Address: HC-86, Box 101, Myrtle Point, OR 97458

Don Walsh is president of International Maritime Inc. (IMI), a marine industry consulting company located in Los Angeles Harbor, California.

Dr. Walsh has been associated with ocean science, engineering, and marine policy for over 30 years. He served as an officer in the U.S. Navy and held the rank of captain at the time of his retirement. He spent 15 years at sea, mostly in submarines, and was the commanding officer of a submarine. In addition, he worked in ocean-related research and development for the U.S. Navy. A former dean of Marine Programs and professor of Ocean Engineering at the

University of Southern California, Dr. Walsh founded and directed the university's Institute for Marine and Coastal Studies. In 1989, his company, International Maritime Inc., formed a joint venture with the P. P. Shirshov Institute of Oceanology to establish an underwater maintenance company, Soyuz Marine Service, which continues to operate in the Russian Federation.

Dr. Walsh has a B.S. in engineering from the U.S. Naval Academy, an M.S. in political science from San Diego State University, and an M.S. and a Ph.D. in physical oceanography from Texas A & M University. He was appointed by Presidents Carter and Reagan to the U.S. National Advisory Committee on Oceans and Atmosphere, was a member of the Law of the Sea Advisory Committee for the U.S. Department of State, and served as a member of the Marine Board of the U.S. National Research Council from 1990 to 1993. Dr. Walsh, along with Captain Picard, has submerged deeper than any human being in a bathyscaph.

OTHER TEAM MEMBERS

Sergey Chechin

Affiliation: Private Consultant for the JTEC/WTEC Office

Address: 244 Hihiiwai St., Apt. #1006, Honolulu, HI 96826

Sergey Chechin is a private consultant for JTEC/WTEC. He is also associated with TEG Ocean Services, which specializes in environmental services. Prior to this he worked with Cotton and Frazier Consultants, Inc. as an environmental scientist where he provided characterization of contaminated sites and performed soil, groundwater, and soil vapor sampling as well as supervised environmental drilling. From 1992 to 1994 Mr. Chechin worked for Atlantis Submarines Hawaii, L.P. as a mechanic. In addition to troubleshooting electronics and electrical and mechanical equipment, he maintained and repaired submarine systems. He also developed the conceptual layout for a unique underwater system for mooring line to facilitate installation/retrieving.

From 1990 to 1991 Mr. Chechin worked in the position of general manager for Telex, a private firm in St. Petersburg, Russia, providing hydrological research and modeling the flow of water in the Gulf of Finland as well as evaluating environmental impact and shoal risks assessment due to the contamination developed by a dam in the Gulf of Finland. From 1977 to 1990 Mr. Chechin worked with Krylov Shipbuilding Institute in St. Petersburg, Russia. By 1983 he had advanced to project manager at which time he supervised design, construction, and modernization of research manned submersibles as well as the on-board research instrumentation.

Mr. Chechin received his M.S. degree in engineering with a specialization in oceanography from the University of St. Petersburg, Russia in 1977.

Michael J. DeHaemer

Affiliation: ASM International

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Dr. DeHaemer is Managing Director of ASM International, a non-profit society dedicated to the advancement of knowledge through exchange of ideas and information on engineered materials. Previously he served as Director of the Japanese Technology Evaluation Center/World Technology Evaluation Center (JTEC/WTEC) at Loyola College, Baltimore, Maryland. He is a former captain and submarine commander in the U.S. Navy. He has also been a founder and director of the Lattanze Human Computer Interface Laboratory, and is a specialist in the applications of synthesized speech and automated voice recognition systems as computer interface output and input.

While on the faculty of the Sellinger School of Business and Management at Loyola College, he served as the chairman of the Information Systems and Decision Sciences Department, where he taught Information Technology and Strategy, the Human-Computer Interface, Applications of Experts Systems and Neural Networks, and Production Management. Dr. DeHaemer has research interests in business applications of artificial intelligence and the methodology of technology assessment. He received his B.S. degree in physics from the University of Notre Dame, his M.S. in operations research from the Naval Postgraduate School, and both his M.B.A. in business administration and industrial engineering and his Ph.D. in management information systems from Rensselaer Polytechnic Institute.



Fig. Bio.1. WTEC panel with Russian hosts at Institute for Marine Technology Problems, Vladivostok. Front, from left: DeHaemer, Ali, Academician Ageev and two staff members. Rear: Chechin, Gentry, Moniz, Walsh, Blidberg, Mooney.

APPENDIX B. PROPOSALS RECEIVED BY ONR AS A RESULT OF THE WTEC SURVEY OF EASTERN RUSSIA

As of April 30, 1996, a total of 29 proposals for research support in Siberia and the Russian Far East had been received by the Scientific Opportunities Program at ONR. The proposals are representative of the strengths in marine-related science and technologies of the nine institutes which submitted them.

Far Eastern State Technical University, Vladivostok

- Fiber Optic Sensing Network, Kulchin
 - Develop longitudinal optical fiber sensors and topology

Institute of Chemistry, Vladivostok

- Battery Technology (cooperation discussions only), Bouznik
 - Develop fluorocarbon-based lithium battery cathodes

Institute of Computational Technologies, Novosibirsk

- Numerical Modeling of Two-Phase Axi-symmetric Flow in Solid Fuel Rockets, Rychkov
 - Computational modeling to calculate parameters of gas flow and particles
- Experimental and Numerical Simulation of Turbulent Swirling Wake, Chernykh with Alekseevitch of Lavrentyev Institute of Hydrodynamics
 - Experimental study and numerical simulation of a swirling wake flow past self-propelled bodies

Institute of Marine Technology Problems, Vladivostok

- Solar-Powered AUV, Ageev
 - Evaluate methods of energy extraction and limiting design parameters of a solar-powered AUV

Institute of Theoretical and Applied Mechanics, Novosibirsk

- Ship Geometry Description Using New Types of Splines, Fomin
 - Develop a variation of spline functions to describe 3-D curves and surfaces
- Riblet Effect on Flow at Laminar Turbulent Transition, Fomin
 - Study effect of artificial vortex structures on laminar-turbulent transition
- Turbulent Bluff-Body Wakes and Acoustic Oscillations, Fomin
 - Study the spatial-temporal structure of the wave field in cavities and associated acoustic radiation

- Acoustic Excitation Control of Instability Waves (suggested research topic only), Fomin
- Cold-Gas Dynamic Spraying Method (suggested research topic only), Fomin
- Numerical (Graphical) Solution of Ship Hydraulic System (suggested research topic only), Fomin
- Simulation of High-Velocity Projectile-Target Interaction (suggested research topic only), Fomin

Institute of Thermophysics, Novosibirsk

- Development of Fast-Prepared Polymers for Drag Decrease, Mamonov
 - Develop in-situ reacting polyethylene oxide pastes for use in drag reduction applications
- Effect of Gas Bubbles on Shock Waves, Pribaturin Micro- and Mesoscale Processes
 - Theoretical and experimental study of gas bubbles' and cavities' effect on shock propagation
- Structure of Helical Vortices, Alekseenko
 - Study influence of boundary conditions and regime parameters on stationary helical vortices
- Drag Reduction Using Microbubble Saturation in Wall Flow, Maltzev
 - Examine gas injection through pores and slots, and gas-water mixture injection for drag reduction
- Cavity Method of Drag Reduction and Jet Flow Control, Maltzev
 - Study of separation and forming of flow and jets for drag reduction
- Synthesis and Physico-Chemical Studies of Fluorocarbon Refrigerants, Alekseenko
 - Measure properties of new ozone-safe refrigerants
- Polymers for Ship Drag Reduction, Semenov
 - Study methods to prevent aggregation of polymer macromolecules in drag reduction solutions
- Compliant Coating Effect on Near-Wall Turbulent Flow, Semenov
 - Establish the effect of compliant drag reduction coatings on drag and pressure fluctuations
- Near-Wall Turbulence Management Through Joint Approach, Semenov
 - Study joint effects of compliant coatings, microbubbles and polymer additives on drag reduction

Lavrentyev Institute of Hydrodynamics, Novosibirsk

- Free Submergence of a Sphere Under the Gravity Force, Bukreev
 - Analysis of data on stability, motion, and drag coefficient of a sphere falling in a fluid
- Physical Principles of Explosive Fabrication of Composite Material, Yakovlev
 - Describe explosive processing of aluminum/titanium/fiber materials using a new approach
- Radiation Instability of the Body Moving in a Stratified Fluid, Sturova
 - Study a body's transfer of translation energy to oscillation energy

Pacific Institute of Bioorganic Chemistry, Vladivostok

- A Potential and Protein Breakthrough, Elyakov
 - Experiments involving growing seaweed on rafts off the coast of Ecuador

Pacific Oceanological Institute, Vladivostok

- Electromagnetic Fields in the Ocean, Medzhitov
 - Study natural ocean electromagnetic fields induced by currents, surface and internal waves, turbulence, etc.
- Geoelectric Methods for Measuring Sea Currents, Medzhitov
 - Develop a new generation of towed or sounding geo-EM sea current measuring instruments
- Electromagnetic Protection of Shallow Sea Areas, Medzhitov
 - Develop a new generation of electromagnetic shallow water personnel sensors
- Monitoring of Mesoscale Processes in Northern Pacific, Shevtsov
 - Study meso- and microscale hydrophysical processes and their effects of sound propagation

APPENDIX C. COMPUTATIONAL AND COMPUTER INFORMATION TECHNOLOGIES

Among 10 research institutes that were visited, 37 different computer software related projects were discussed or demonstrated. A complete listing by institute is given below. See the individual site reports for further details.

Far Eastern State Technical University, Vladivostok

- IBM 486-based CAD laboratory
- Ocean tomography
- Two-layer neural network for measurement processing

Institute of Automation and Control Processes, Vladivostok

- Expert systems
- Expert systems software to develop other expert systems
- Reliability and maintenance software tools
- Silicon-based semiconductor research

Institute of Automation and Electrometry, Novosibirsk

- New information technologies
- Task-oriented computer systems
- X-ray tomography algorithms
- Digital image processing in high noise
- CD diffractive data storage
- Pattern recognition algorithms

Institute of Chemistry, Vladivostok

- Numerical modeling of sorption processes

Institute of Computational Technologies, Novosibirsk

- Computational hydrodynamics
- Computational physics
- Implementing Internet access for all Akademgorodok institutes, then to Moscow via satellite

- Communications and data base of scientific information
- Data reconstruction algorithms, correcting for random errors
- Expert systems
- Production rules
- Non-classical logic
- Decision support in event of natural disasters
- Software support to research institutes (no specific examples given)
- Simulations on 486 PC, fairly detailed
- Tsunami prediction model

Institute of Marine Technology Problems, Vladivostok

- Guidance/navigation and control algorithms development for Autonomous Underwater Vehicles

Institute of Thermophysics, Novosibirsk

- Good local, HP-equipped, computer network
- Microchip soldering technique, under contract to HP

Institute of Theoretical and Applied Mechanics, Novosibirsk

- Mathematical modeling of explosive performance
- Computer controlled wind tunnels (8); working on LAN to link all facilities

Lavrentyev Institute of Hydrodynamics, Novosibirsk

- Mathematical hydrodynamics modeling
- Underwater explosive effects and performance modeling
- Prediction of safety of initiation and detonation processes

Pacific Oceanological Institute, Vladivostok

- Mathematical modeling of hydro-acoustics

JTECH Panel Report on Computer Science in Japan
(12/84) PB85-216760

JTECH Panel Report on Opto and Microelectronics (5/85)
PB85-242402

JTECH Panel Report on Mechatronics
in Japan (6/85) PB85-249019

JTECH Panel Report on Biotechnology
in Japan (5/86) PB85-249241

JTECH Panel Report on Telecommunications
Technology in Japan (5/86) PB86-202330/XAB

JTECH Panel Report on Advanced Materials (5/86) PB86-
229929/XAB

JTECH Panel Report on Advanced Computing in Japan
(12/87) PB88-153572/XAB

JTECH Panel Report on CIM and CAD for
the Semiconductor Industry in Japan (12/88)
PB89-138259/XAB

JTECH Panel Report on the Japanese Exploratory Research
for Advanced Technology (ERATO) Program (12/88)
PB89-133946/XAB

JTECH Panel Report on Advanced Sensors in Japan (1/89)
PB89-158760/XAB

JTEC Panel Report on High Temperature
Superconductivity in Japan (11/89)
PB90-123126

JTEC Panel Report on Space Propulsion in Japan (8/90)
PB90-215732

JTEC Panel Report on Nuclear Power in Japan (10/90)
PB90-215724

JTEC Panel Report on Advanced Computing in Japan
(10/90) PB90-215765

JTEC Panel Report on Space Robotics in Japan (1/91)
PB91-100040

JTEC Panel Report on High Definition Systems in Japan
(2/91) PB91-100032

JTEC Panel Report on Advanced Composites in Japan
(3/91) PB90-215740

JTEC Panel Report on Construction Technologies in Japan
(6/91) PB91-100057

JTEC Program Summary (9/91) PB92-119429

JTEC Panel Report on X-Ray Lithography in Japan (10/91)
PB92-100205

WTEC Panel Report on European Nuclear Instrumentation
and Controls (12/91) PB92-100197

JTEC Panel Report on Machine Translation in Japan (1/92)
PB92-100239

JTEC Panel Report on Database Use and Technology in
Japan (4/92) PB92-100221

JTEC Panel Report on Bioprocess Engineering in Japan
(5/92) PB92-100213

JTEC Panel Report on Display Technologies in Japan
(6/92) PB92-100247

JTEC Panel Report on Material Handling Technologies in
Japan (2/93) PB93-128197

JTEC Panel Report on Separation Technology in Japan
(3/93) PB93-159564

JTEC Panel Report on Knowledge-Based Systems in Japan
(5/93) PB93-170124

NASA/NSF Panel Report on Satellite Communications
Systems & Technology (7/93):
Executive Summary PB93-231116
Vol. I. Analytical Chapters PB93-209815
Vol. II. Site Reports PB94-100187

WTEC Monograph on Instrumentation, Control & Safety
Systems of Canadian Nuclear Facilities (7/93)
PB93-218295

JTEC/WTEC Annual Report and Program Summary
1993/94 (3/94) PB94-155702

JTEC Panel Report on Advanced Manufacturing
Technology for Polymer Composite Structures in Japan
(4/94) PB94-161403

ITRI Monograph on Benchmark Technologies Abroad:
Findings From 40 Assessments, 1984-94 (4/94) PB94-
136637

WTEC Panel Report on Research Submersibles and
Undersea Technologies (6/94) PB94-184843

JTEC Panel Report on Microelectromechanical Systems in
Japan (9/94) PB95-100244

WTEC Panel Report on Display Technologies in Russia,
Ukraine, and Belarus (12/94) PB95-144390

JTEC Panel Report on Electronic Manufacturing and
Packaging in Japan (2/95) PB95-188116

JTEC Monograph on Biodegradable Polymers and Plastics
in Japan (3/95) PB95-199071

JTEC Panel Report on Optoelectronics in Japan and the
United States (2/96) PB96-152202

JTEC Panel Report on Human-Computer Interaction
Technologies in Japan (3/96) PB96-157490

WTEC Panel Report on Submersibles and Marine
Technologies in Russia's Far East and Siberia (8/96)
PB96-199526